NORTH ATLANTIC TREATY ORGANIZATION

SCIENCE AND TECHNOLOGY ORGANIZATION

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STO TECHNICAL REPORT **TR-HFM-193**

Traumatic Brain Injury in a Military Operational Setting

(Le traumatisme crânien dans un cadre militaire opérationnel)

This Report summarizes the findings of Task Group 193. The objectives of which were to summarize current knowledge and practices in managing mild traumatic brain injury which occurs in a military operational setting.

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Traumatic Brain Injury in a Military Operational Setting

(STO-TR-HFM-193)

Executive Summary

Mild Traumatic Brain Injury (MTBI), also known as concussion, as a consequence of battlefield blast exposure or blunt force trauma has been of increasing concern to militaries during recent conflicts. Consequently, this Task Group was formed in 2009 with the objectives of providing some clarity to military medical leadership to inform their decisions in the management of deployment-related MTBI. The objectives of this report were to:

1) Describe current existing clinical practice for all participating NATO Nations;
2) To identify existing gaps in knowledge;
3) Provide a summary of current research projects and predicted target dates for completion; and finally
4) Elucidate principles for best practices.

Blasts can lead to MTBI through a variety of mechanisms, which are discussed in detail in Chapters 2 and 7. Debate continues as to whether exposure to a primary blast wave alone is sufficient to create brain injury in humans, and if so, exactly how this occurs with an intact skull. However, experience has shown that most individuals who sustain MTBI as a result of blast exposure manifest multiple blast effects and it is not possible to determine the relative contribution of the primary blast wave versus that caused by flying debris and acceleration/deceleration or rotation.

The public health impact of deployment-related MTBI upon any military can only be captured through the conduct of sound epidemiologic studies that ascertain the degree of exposure to potential injury mechanisms, the numbers injured as a result of exposure, and the clinical course of recovery. Challenges to our understanding of the epidemiology arise from the lack of a consistently applied definition of MTBI and from the fact that MTBI is itself a heterogeneous entity with injury severity ranging from a brief period of being dazed and confused to loss of consciousness up to 30 minutes. International consensus on an evidence-based definition would be of great value. Studies conducted to date have shown that the clinical course of blast-induced MTBI largely parallels that seen in the sports literature, with most individuals showing resolution of symptoms and impairments within days to weeks. This is not necessarily the case in those who sustain multiple concussions, in which recovery may take longer. While many who sustain multiple concussions ultimately show full resolution of symptoms, others do not. We are very early in our understanding of this condition, and the factors that may contribute to differing outcomes following MTBI events.

There is considerable range as to how the participating NATO Nations currently approach MTBI. To a large extent, this may reflect the degree of exposure to potential injury mechanisms faced by their respective deployed forces as well as their relative levels of confidence that current approaches are adequate and appropriate. Current clinical practice guidelines instituted by Canada, the United States and the United Kingdom are summarized in Chapter 6. All three have adopted similar definitions of MTBI. Although there are differences in the approaches adopted by these countries, there are also common fundamental elements. Most of these clinical practice guidelines have been developed through expert opinion, largely based on paradigms employed in the sports literature. Few, if any, have been systematically evaluated in a rigorous

methodological fashion to determine if they improve outcomes. Moving forward, future promulgation of any clinical practice guidelines should have a built-in evaluation framework to determine whether, and the extent to which, they are efficacious.

Le traumatisme crânien dans un cadre militaire opérationnel

(STO-TR-HFM-193)

Synthèse

Le traumatisme crânien léger (TCCL), également appelé commotion cérébrale, suite à une exposition à une déflagration sur le champ de bataille ou d'un traumatisme contondant, a été une préoccupation croissante des militaires au cours de conflits récents. Par conséquent, ce groupe de travail a été constitué en 2009 dans le but d'apporter un peu de clarté aux autorités médicales militaires, afin d'éclairer leurs décisions dans la gestion du TCCL lié à un déploiement. Les objectifs de ce rapport étaient de :

1) Décrire la pratique clinique existant actuellement dans toutes les nations de l'OTAN ;
2) Identifier les lacunes des connaissances existantes ;
3) Fournir une synthèse des projets de recherche actuels et leurs dates prévues pour l'achèvement ; et enfin
4) Préciser les principes des bonnes pratiques.

Les déflagrations peuvent entraîner un TCCL par divers mécanismes, qui sont discutés en détail dans les Chapitres 2 et 7. Le débat se poursuit afin de savoir si la seule exposition à une onde de souffle primaire suffit à créer une lésion cérébrale chez l'homme et, dans ce cas, comment elle s'est produite exactement pour un crâne intact. Toutefois, l'expérience a montré que la majeure partie des personnes qui subissent un TCCL à la suite d'une déflagration manifestent des effets de souffle multiples, et il n'est pas possible de déterminer la part de contribution de l'onde de souffle primaire par rapport à celle de la projection de débris et à l'accélération/décélération ou rotation.

L'impact sur la santé publique du TCCL lié à un déploiement sur tout militaire ne peut uniquement être approché que par le recours à des études des conséquences épidémiologiques constatant le degré d'exposition à des mécanismes lésionnels potentiels, le nombre de personnes blessées suite à l'exposition et le processus clinique de récupération. Les défis à notre compréhension de l'épidémiologie proviennent du manque d'une définition du TCCL appliqué de manière cohérente et du fait que le TCCL en question est une entité hétérogène avec une gravité de blessures allant d'une brève durée d'hébétude et de confusion à une perte de conscience pouvant atteindre 30 minutes. Le consensus international sur une définition fondée sur l'expérience serait très appréciable. Les études réalisées jusqu'à maintenant ont montré que le cours clinique du TCCL provoqué par une déflagration présente de forts parallèles avec ce qu'on constate dans la littérature sur le sport, la majeure partie des personnes voyant leurs symptômes et déficiences disparaître en quelques jours ou quelques semaines. Ce n'est pas nécessairement le cas chez ceux qui ont subi des commotions multiples, pour lesquels la guérison peut prendre plus de temps. Si beaucoup des personnes ayant subi des commotions multiples présentent en fin de compte une totale guérison des symptômes, ce n'est pas le cas pour d'autres. Nous en sommes aux premiers stades de notre compréhension de cet état et les facteurs pouvant contribuer à des résultats différents après les événements de TCCL.

Il existe actuellement une variété considérable d'approches du TCCL parmi les nations de l'OTAN. Dans une large mesure, elles peuvent refléter le degré d'exposition à des mécanismes lésionnels potentiels auxquels leurs forces respectives déployées sont confrontées, tout comme leurs niveaux relatifs de confiance que les approches actuelles sont adaptées et appropriées. Les directives de pratique clinique actuelles

instituées par le Canada, les Etats-Unis et le Royaume-Uni sont résumées au Chapitre 6. Les trois pays ont adopté des définitions similaires du TCCL. Bien qu'il existe des différences dans les méthodes adoptées par ces pays, il y a aussi des éléments fondamentaux communs. La plupart de ces directives de pratique clinique ont été développées après avis d'experts, largement basés sur les paradigmes utilisés dans la littérature du sport. Le cas échéant, peu ont été systématiquement évalués d'une manière méthodologique rigoureuse afin de déterminer s'ils améliorent les résultats. Pour aller de l'avant, toute future promulgation de directives de pratique clinique devrait avoir un cadre d'évaluation intégré afin de définir si, et dans quelle mesure, elles sont efficaces.

Chapter 1 – INTRODUCTION: RELEVANCE OF MILD TRAUMATIC BRAIN INJURY IN A DEPLOYED SETTING

Bryan Garber, Thomas Balkin and Eric Vermetten

1.1 BACKGROUND

The emergence into the public consciousness of Mild Traumatic Brain Injury (MTBI) during military operations largely arose from the combat experiences of the United States (US) of America in the wars in Afghanistan and Iraq.

Early reports from those wars indicated that Traumatic Brain Injury (TBI) accounted for a larger proportion of casualties than in other recent US wars. Injuries to the head, face and neck were present in 22% of wounded soldiers evacuated from theatre [1]. In contrast, only 12 – 14 % of all combat casualties in the Vietnam War were diagnosed with a brain injury.

There are several possible reasons for this discrepancy [1]. First, the mortality during the Vietnam War from head injury was 75% or greater, with few head-injured personnel surviving long enough to reach a hospital. Second, improvements in personal protective equipment have more effectively shielded soldiers from penetrating injuries. Finally, the insurgent weapon of choice has been the Improvised Explosive Device (IED). Blast has been the predominant mechanism of injury for most deployment associated TBI, and closed-head injuries have outnumbered penetrating ones in those soldiers seen at the Walter Reed Army Medical Center. Of those injured by blast exposure, 59% were given a diagnosis of TBI, of which 44% were mild [1].

1.2 FULL SPECTRUM OF INJURY (MILD, MODERATE, SEVERE)

The early reports by Warden [2] and Okie [1] demonstrated that blast-induced brain injuries encompassed the full range of severity, but it is MTBI that has garnered the most attention. This is because MTBI symptoms can be subtle and therefore can easily be overlooked or discounted by both the soldier and the medical provider – but such mild deficits could nevertheless increase risk to self and others if manifested in the military operational environment. Moreover, the potentially larger numbers of soldiers who are affected by MTBI as a consequence of blast exposure, versus moderate or severe TBI, may have greater cumulative operational impact, even though the long-term sequelae are not as salient as more severe brain injuries.

1.3 DEFINING THE PROBLEM

In 2006, The US Defense Veterans and Brain Injury Center (DVBIC) Working Group adopted the following definition of MTBI [3], as did the Canadian Armed Forces in 2008 [4]. The definition is as follows:

> *Mild TBI in military operational setting is defined as an injury to the brain resulting from an external force and/or acceleration/deceleration mechanism from an event such as a blast, fall, direct impact, or motor vehicle accident which causes an alteration in mental status typically resulting in the temporally related onset of symptoms such as: headache, nausea, vomiting, dizziness/balance problems, fatigue, insomnia/sleep disturbances, drowsiness, sensitivity to light/noise, blurred vision, difficulty remembering, and/or difficulty concentrating.*

The definition has since been modified by the US DoD [5] to endorse biomechanical forces as a cause of concussion that results in an acute alteration of awareness to include: Loss Of Consciousness (LOC), Post-Traumatic Amnesia (PTA) which may be anterograde or retrograde, or Alteration Of Consciousness (AOC) such as being dazed and confused. LOC is not a required characteristic. These definitions were adapted from other existing definitions derived from a civilian setting, including: the American College of Rehabilitation Medicine (1993) [6]; the Centers for Disease Control and Prevention (CDC, 2003) [7]; the World Health Organization (2004) [8]; the National Athletic Trainer's Association (2004) [9]; and, the Prague Sports Concussion Guidelines (2005) [10].

It has been argued that symptoms of being dazed, confused and seeing stars, as well as transient loss of consciousness and not remembering the injury, can be caused by severe stress as well as by MTBI, making differential diagnosis more difficult [11], [12]. This may be further potentiated by retrospective accounts of injury, because during recall of trauma reactions, people with psychological disturbances can overestimate both the symptoms that they had in the acute phase, as well as their exposure to harm [12]. Until objective and practical field-based diagnostic tests are developed that can reliably distinguish between acute stress reactions and MTBI, misclassification will continue to hamper efforts to understand and manage those injured by blasts.

Despite these limitations, use of an agreed-upon operational definition would facilitate efforts to conduct MTBI research, interpret data, and generalize findings across all NATO Nations and Partners.

1.4 BLAST MECHANISM

The notion that blast exposure causes head injury is not a new concept. Indeed, it is well known that blast can cause injury to human beings through a variety of mechanisms, and these are discussed more thoroughly in Chapter 7.

Of course, the fact that exposure to blasts can cause injury by a direct blow to the head is indisputable. What has fuelled the increased concern (and debate) about MTBI in the military context is the possibility that a potentially large number of undiagnosed cases exist – as the result of pure primary blast wave exposure. This has been the subject of an extensive amount of research and will be discussed later in this report.

1.5 SHELL-SHOCK REVISITED

Skeptics have argued that increasing concern about MTBI as a consequence of blast exposure has re-ignited the debate about shell-shock that arose during World War I [13]. The term shell-shock formally entered the medical lexicon with Capt. C.S. Myers' publication in the *Lancet* in February 1915. Soldiers who had been close to a detonation without receiving an obvious head wound frequently presented with amnesia, poor concentration, headache, tinnitus, hypersensitivity to noise, dizziness and tremor.

Shell-shock was formulated as an organic problem, but the pathology remained unclear. However, subsequent investigations identified that many shell-shocked soldiers had not been in proximity to a blast but presented with symptoms identical to those who had. For such cases, the term "emotional" rather than "commotional" shock was proposed.

The scale of this disorder became immense to the extent that during World War I, 10% of British battle casualties were categorized as some form of shell-shock or neuroasthenia, and 32,000 British war pensions were awarded for shell-shock.

Although the British Government banned the use of the term shell-shock at the beginning of the Second World War, soldiers who were near explosions continued to present with a variety of symptoms that were subsequently called post-concussion syndrome. Despite extensive experience with concussion during conflict and in the civilian setting, post-concussive syndrome remains poorly understood. As will be discussed later, the clinical picture in such cases is complicated by the overlap of symptoms with other disorders.

1.6 HIDDEN WOUNDS OF WAR IN CURRENT TIMES

Fast-forward to current times, and the observations by Warden [2], Okie [1] and others have raised the concern that far more military personnel had suffered a MTBI than was generally appreciated by authorities. A study published by the RAND Corporation estimated that up to 300,000 US service personnel deployed to Operations Enduring Freedom and Operation Iraqi Freedom sustained possible MTBI, although most were asymptomatic at the time of the survey, consistent with the known pattern of recovery for this injury [14].

More current estimates that come from post-deployment screening show that up to 10 to 20 % have sustained an MTBI. Clearly, the risk is directly related to the degree of exposure to combat, IED, rocket, artillery and mortar attacks, and so will vary among NATO Nations and Partners in accordance with their respective rates of exposure to such events.

1.7 RELEVANCE OF MTBI DURING DEPLOYMENT

Those who have sustained a MTBI in theatre typically experience a transient and reversible impairment in consciousness and executive function that potentially makes them a risk to themselves and others, until they have fully recovered. The primary goals of in-theatre management are to differentiate mild from more severe injuries and to assess fitness for duty in those with mild injuries. Management strategies that have been adopted by some NATO Nations and Partners are largely modeled on clinical guidelines developed in the sports literature. Those guidelines utilize available evidence but where evidence is lacking, are based on expert opinion. Their use in the military context has not been adequately evaluated.

Similarly, different approaches have been used by NATO Nations and Partners for case identification: self-reporting and event-based screening. The latter relies on successful penetration of educational strategies targeted toward line personnel, in which the need to undergo evaluation is emphasized when there is a reasonable possibility of an MTBI. This is the same strategy used in the civilian sports setting. Event-based screening requires mandatory screening for all personnel following a specified event. Again, the effectiveness of these two strategies and their public health and operational impact in the military operational setting have yet to be determined.

1.8 RELEVANCE OF MTBI POST-DEPLOYMENT

Some NATO Nations and Partners routinely screen deployed personnel in the post-deployment period for a number of disorders and have modified these screening programs to capture in-theatre MTBI history. As will be reviewed in the section on the epidemiology of MTBI (Chapter 3), estimates vary as to the number of cases identified. However, most are found to be asymptomatic 3 – 6 months after deployment.

Here, the military experience parallels that seen in civilian settings, where a minority of cases of MTBI have persistent symptoms [15]. The more common of these symptoms often occur together and have been given varying terms such as post-concussion syndrome or post-concussion disorder [16]. There is little uniformity in

the identification of predictors of delayed recovery after MTBI [15], due to inconsistency in the predictors studied, and an absence of confirmatory studies. Moreover the symptoms that may occur following concussion (e.g., headache, dizziness, fatigue, irritability, insomnia, memory or concentration difficulties) can overlap with symptoms of other conditions, further complicating the ability to attribute symptoms to a specific cause. This has been demonstrated in at least one prospective study in a civilian trauma population that showed that the prevalence of such symptoms was comparable in trauma patients with and without head injury [17].

Those who experience a multitude of symptoms many months following a history of deployment-related MTBI present a complex clinical picture. Soldiers who have returned from deployment to a combat zone frequently experience ill health from a variety of causes, many of which are not well understood. Abundant data have revealed that a considerable minority of soldiers returning from combat experience psychological illnesses such as Post-Traumatic Stress Disorder (PTSD), depression and substance abuse [18]-[20]. Others experience a variety of medically unexplained physical symptoms, an observation that initially emanated from Operation Desert Storm but is now generally recognized to have existed prior to that particular conflict [21]. The diagnostic dilemma is further compounded by the fact that, as mentioned previously, post-concussive symptoms are common in the general population and are non-specific [17].

1.9 MTBI AND PSYCHIATRIC MORBIDITY

Reminiscent of the debate on shell-shock in WWI, some have argued that in the military context, PTSD and depression are important mediators of the relationship between MTBI and physical health outcomes [22]. A study published in 2008 on health outcomes in US Army Infantry Soldiers 3 – 4 months after deployment revealed that soldiers with MTBI − primarily those who had experienced loss of consciousness − were significantly more likely to report poor general health, missed work days, medical visits, and a higher number of somatic and post-concussive symptoms than soldiers with non-head injuries. However, after controlling statistically for PTSD and depression, mild traumatic brain injury was no longer significantly associated with these physical health outcomes or symptoms, except for headache. Since then, others have published similar observations [23]-[26]. Whether, and the extent to which, persistent symptoms following MTBI are manifestations of unhealed neurologic injury, undiagnosed psychiatric disorder, or both, will likely remain a topic of contentious debate until objective, gold standard diagnostic tests of MTBI have been developed.

1.10 MULTIPLE MILD TRAUMATIC BRAIN INJURIES

There has been increasing attention on the potential immediate and long-term consequences of multiple MTBIs, also known as concussions. Unfortunately, while the effect of a single concussion on cognitive measures has been relatively well studied, data on the impact of multiple concussions is limited. Nearly all of this literature is derived from the sports-related injuries, and findings have been inconsistent with respect to the adverse long-term effects after experiencing two or more concussions. For example, some studies have found adverse long-term effects on cognitive performance [27], [28], whereas others have not [29]-[32]. Similarly, some studies have found that athletes with two or more prior concussions recover more slowly [33], [34], while other studies find no relationship between recovery time and concussion history [35].

In a recently published meta-analysis of data from 10 studies on sports-related MTBI, 614 cases of multiple MTBI were compared to 926 cases of single MTBI [36]. The authors found no overall significant effect on neurocognitive functioning or symptom complaints among those with multiple concussions, although there were non-significant trends toward poorer performance on delayed memory and executive functioning tests. The studies used in this meta-analysis included participants who reported an average of between two and three

concussions. The possibility that there may be a threshold effect has yet to be determined. Indeed, another meta-analysis based on the *number* of concussions did find a significant effect on cognitive performance using number of boxing bouts, length of boxing career, and/or frequency of heading in soccer as the measure of exposure [37]. Further work is needed to determine whether such a threshold exists, and if so, where that threshold lies; although it is likely to differ from person to person, and to depend on factors such as the force of the impacts and severity of the concussions.

1.11 THE ROAD AHEAD

The goals for this technical report are to:

1) Describe existing clinical practice for all participating NATO Nations;
2) Identify existing gaps in knowledge;
3) Provide a summary of current research projects and predicted target dates for completion; and where possible
4) Elucidate principles for best practices.

It is important to emphasize that there is no 'right' program. Where possible, clinical diagnosis and management strategies should be evidence-based, and where lacking, guided by a judicious approach commensurate with the level of risk. Each NATO Member Nation needs to explore the magnitude of this issue within the context of the scope of their own military operations before deciding on an approach that best suits their circumstances. Whatever approach is ultimately adopted needs to be balanced, logical, feasible and based on the best available scientific evidence. Continued vigilance is required to identify compelling new evidence that would warrant changes in practice.

Chapter 2 – WHITE PAPERS

All Authors Contributed to this Chapter

2.1 NEED FOR A NATO STANDARD DEFINITION OF MILD TRAUMATIC BRAIN INJURY (MTBI)

2.1.1 Purpose

To present the need for a standard definition of MTBI among NATO countries.

2.1.2 The Challenge

Different consensus definitions of MTBI have been developed and published in the literature, including those by: the American College of Rehabilitation Medicine [6]; the Centers for Disease Control and Prevention (CDC) [7]; the World Health Organization (WHO) [8]; the National Athletic Trainer's Association [9]; the VA/DoD Clinical Practice Guidelines (2009) [5]; and, the Prague Sports Concussion Guidelines [10].

The WHO and CDC MTBI definitions have been most commonly used in research. The Unites States VA/DoD Clinical Practice Guidelines [5] adheres to these, and utilizes the characteristics of loss or alteration of consciousness, post-traumatic amnesia, and the absence of neuroimaging abnormalities. The Canadian Armed Forces has adopted a similar definition [4].

These definitions all endorse biomechanical forces as a cause of MTBI that result in an acute alteration of consciousness that includes: being dazed and confused, Loss Of Consciousness (LOC), or post-traumatic amnesia. All definitions provide maximum lengths of unconsciousness and post-traumatic amnesia in order to distinguish mild from moderate or severe TBI.

2.1.3 Relevance for NATO

In order to ensure optimal clinical care of military personnel who have sustained a MTBI whenever they are evaluated at any NATO medical facility, a common definition with agreed-upon clinical criteria is necessary. Having a common operational definition of MTBI is the basis of consistent case ascertainment, development of shared diagnostic assessment tools, clinical management strategies, and the ability to compare findings from scientific investigations.

2.2 BLAST-INDUCED INJURIES AND MTBI

2.2.1 Purpose

To present an overview of blast injuries and MTBI.

2.2.2 The Challenge

The relationship between explosive detonations and alterations in brain function has been a concern since World War I. Concerns have been raised about the ability to attribute symptoms to psychological reactions versus physical injuries.

The use of Improvised Explosive Devices (IEDs) by enemy combatants has resulted in a growing number of military service members and civilians having been exposed to blast waves and who suffer from the secondary, tertiary or quaternary effects of blast, in addition to injuries that are result of direct exposure to blast waves. Recent improvements in body and vehicle protection have resulted in decreased mortality but greater morbidity, including Traumatic Brain Injury (TBI).

MTBI accounts for the vast majority of documented TBI cases in the operational environment, and is often accompanied by stress and psychological trauma from the causative event. Most cases of MTBI have limited detectable structural brain lesions identified. However, advanced imaging techniques have detected structural brain lesions in more MTBI cases than earlier imaging techniques, and are promising. Some with MTBI have functional effects that last for a considerable amount of time; the underlying factors associated with chronic effects remain to be established. The physics of blast injury are different compared to non-blast trauma reported in the civilian setting [38].

One way to understand the effects of a blast wave is to divide the mechanism into:

- **Primary Effects of Blast:** The blast wave involves supersonic pressure changes over a very short time frame. The threshold for injuries is determined by factors such as peak pressure, duration and shape of the blast wave (reflections, underpressure, etc.). The effects of blast on organs such as the lungs and ears are well known, but the potential effects on the central nervous system are still being studied.
- **Secondary Effects of Blast:** The blast wave can generate flying objects, such as shrapnel fragments, which can cause penetrating and blunt force injuries.
- **Tertiary Effects of Blast:** The blast wave can cause the individual to be physically moved. Such acceleration movements can result in tissue shearing and diffuse injuries within the brain, such as Diffuse Axonal Injuries (DAI) in nerve fiber tracts.
- **Quaternary Effects of Blast:** Quaternary effects are due to heat, smoke (involving toxins) or emission of electromagnetic pulses. There is no evidence for negative effects of electromagnetic pulses on the central nervous system at present.

2.2.3 Relevance for NATO

The majority of battlefield MTBI cases are due to one or more of these blast injury mechanisms, e.g., blast wave pressure combined with flying objects or acceleration movements. However, data on the characteristics of blast exposure are usually not available. Blast-related TBI resulting in brain edema and vascular spasm should be assumed to be the result of a combination of more than one blast injury mechanism.

There is not enough information to determine whether a primary blast alone can induce MTBI or if other blast injury components are required. Experimental studies have revealed functional changes in animals, but the translation of experimental research is not yet sufficient to conclude that similar functional changes result in the development of clinical symptoms of MTBI, post-traumatic stress disorder or other clinical conditions in humans.

2.3 CONSEQUENCES OF MTBI ON MILITARY OPERATIONS

2.3.1 Purpose

To present an overview of the consequences of MTBI on operational readiness, individual and family functioning, and health-care delivery systems.

2.3.2 The Challenge

MTBI is a military relevant issue due to its incidence and prevalence both in deployed and non-deployed settings. Although blast is frequently the precipitating event resulting in TBI in current NATO conflicts, other mechanisms such as falls, falling debris, sports injuries and motor vehicle crashes also occur and must be taken into account.

Acutely, symptoms from MTBI may impact operational readiness of the individual or unit. In most cases, the acute effects are of short duration, but an important minority of individuals with MTBI have a prolonged course of recovery. Consequences of MTBI impact the health of individuals in the short term, can affect their ability to remain in theatre, and potentially affect their ability to deploy in the future if symptoms fail to resolve.

Failure to identify or recognize individuals who are impaired as a result of MTBI can have serious consequences for them, their comrades, and the mission. Programs and policies that are implemented to manage MTBI have the potential to impact the military operation in a positive or negative way. Positive impacts include appropriate early identification of injured personnel. Potential negative effects include unnecessary removal of personnel from operational duties.

From a societal perspective, the way the military deals with MTBI may influence public perception of the military commitment to the care of service members. This, in turn, may influence public and individual resolve to remain in the fight.

2.3.3 Relevance for NATO

There is considerable variability in how NATO Nations have chosen to approach this issue. To some extent, this may be due to national variability in the nature and duration of deployments as well as the number of service members deployed. Ultimately, a sound approach should be informed by evidence relevant to each Nation's forces. Decisions about the implementation of programs, policies and guidelines should be guided by such results and aided by the use of sound public health organizing frameworks.

Evidence-based public health policy is best served by the use of an evaluation framework such as Population Impact Analysis [39]. Such organizing frameworks can be used to apply evidence when estimating the impact of program and policy implementation.

2.4 RETURN-TO-DUTY CONSIDERATIONS IN THOSE WITH A CLINICAL DIAGNOSIS OF MTBI

2.4.1 Purpose

To present an overview of the need to establish objective Return-To-Duty (RTD) criteria.

2.4.2 The Challenge

MTBI is increasingly recognized in sports medicine where significant focus has been placed on evaluation of injured athletes with specific criteria for return to play. Evidence-based RTD criteria are essential for injured military personnel in deployed environments. MTBI affects both mission readiness and individual health. Consideration of the cumulative impact of multiple concussions should be included in the RTD decision-making process.

2.4.3 Return-to-Duty Considerations

There is no single established objective criterion for RTD, nor validated tools with which to guide RTD decision making in military operational settings. The following factors may be considered in RTD decisions:

- **Symptoms –** The absence of symptoms is widely accepted as minimal criteria for RTD.
- **Physical Examination –** Physical examination, which includes a neurological exam, should be normal prior to RTD.
- **Concussion History –** The number, severity, and recency of prior concussions should factor into RTD considerations.
- **Exertional Testing –** Exertional testing [4], [5] with symptom monitoring can inform RTD determination:
    1) Exert to 65 – 85 % of target heart rate (THR = 220-age) using push-ups, sit-ups, running place, step aerobics, stationary bike, treadmill and/or hand crank;
    2) Maintain this level of exertion for approximately 2 minutes;
    3) Assess for symptoms (headache, vertigo, photophobia, balance, dizziness, nausea, visual changes etc.); and
    4) If symptoms exist with exertional testing, stop testing, and allow additional time for rest and recovery until asymptomatic.
- **Cognitive Testing –** Quick assessment tools (Standardized Assessment of Concussion [SAC], Military Acute Concussion Evaluation [MACE]) and/or more detailed neurocognitive testing in the appropriate settings may aid in RTD determinations.

Other technologies, such as neuroimaging, biomarkers, etc., have yet to demonstrate sufficient sensitivity and specificity for routine use in RTD determinations.

2.4.4 Relevance for NATO

The development of comprehensive policies and practices regarding RTD determination after MTBI is essential to promote mission readiness and enforces a standard and consistent approach to RTD.

At a minimum, those policies should consider criteria identified above.

2.5 TOWARDS A GOLD STANDARD FOR MTBI DIAGNOSIS

2.5.1 Purpose

To present an overview of the need for gold standard clinical and biomarker assessments for MTBI diagnosis.

2.5.2 The Challenge

The diagnosis of MTBI currently relies on clinical characteristics at the time of injury. In a military operational setting, acute evaluation at the time of injury is not always feasible and therefore the diagnosis is often made based on retrospective self-report or witness report of those clinical characteristics. In addition, polytrauma or acute stress associated with a life threatening combat event may confound the diagnosis of a MTBI.

Early identification and diagnosis of MTBI allows for early intervention and improved outcomes. Therefore, objective diagnostic tools, particularly those that can be used near the point of injury, are of great interest.

A gold standard diagnostic tool is one of known validity and reliability which is generally accepted to be the best available, against which new tests or results and protocols are compared [40]. The current approach to MTBI diagnosis relies on a comprehensive history of the injury event and immediate symptoms that follow, and physical examination including neurologic and cognitive assessments. There are currently no validated tests to objectively diagnose MTBI.

Potential objective diagnostic tools may be categorized as follows:

- Advanced neuroimaging techniques (such as MRI diffusion tensor imaging, PET-CT, high-resolution fiber tracking, etc.);
- Blood biomarkers;
- Electrophysiologic markers (such as quantitative EEG, event-related potentials);
- Measures of cerebral blood flow and intracranial pressure;
- Neurocognitive assessments; and
- Sensory assessment tools (olfaction, auditory, vestibular).

2.5.3 Relevance for NATO

Currently, the gold standard for making a diagnosis of MTBI relies exclusively on clinical characteristics and clinical evaluations. Objective diagnostic tools such as advanced neuroimaging techniques, blood biomarkers, electrophysiologic markers, neurocognitive assessments, and sensory assessment tools hold promise singularly or in combination, but require additional research to validate their sensitivity, specificity, and reliability, and demonstrate practicality before they can be considered a standard of care.

An agreed-upon diagnostic strategy among NATO Nations would allow for a common understanding and would help coordinate future research, surveillance, and evaluation of deployment health outcomes.

2.6 ASSESSMENT AND MANAGEMENT OF MTBI IN MILITARY OPERATIONAL SETTINGS

2.6.1 Purpose

To present issues related to the assessment and management of MTBI in military operational settings.

2.6.2 The Challenge

There is a paucity of scientific evidence related to the assessment and management of MTBI. Most of the available literature is based on civilian cohorts that were not randomized, controlled studies. There are many ongoing research studies being conducted within military populations. Policy and clinical guidance about MTBI assessment and treatment vary considerably among NATO Nations. Early detection facilitates successful resolution of symptoms and optimal management [41]-[43]. Therefore, the need for validated assessment tools and effective treatments remain a priority.

Common assessments used after MTBI in the deployed setting include the following:

- History, physical and neurological examination, symptom screening;
- Military Acute Concussion Evaluation (MACE);
- Neurobehavioral Symptom Inventory (NSI);
- Automated Neuropsychological Assessment Metrics (ANAM);
- Immediate Post-concussion Assessment and Cognitive Testing (ImPACT); and
- Glasgow Coma Scale (GCS).

2.6.3 Relevance for NATO

Adopting a NATO standardized approach to assessment and management will optimize care. The mainstay of treatment remains early education and rest until recovery. The use of validated assessment tools and effective treatments for MTBI will support best care practices known at this time. In addition, this information can be leveraged to help further the development of validated assessment tools used in MTBI, as well as effective treatments.

2.7 THE RELATIONSHIP BETWEEN MTBI AND POST-TRAUMATIC STRESS DISORDER

2.7.1 Purpose

To address the relationship between MTBI and PTSD.

2.7.2 The Challenge

The relationship between MTBI and PTSD is not fully understood. There is no universally accepted objective diagnostic standard for either condition, although there is significant overlap in symptom presentation. Due to this overlap in symptoms, there is ambiguity about attribution of persistent symptoms to MTBI or PTSD.

The majority of people (approximately 85 – 90 %) in civilian sports populations who experience MTBI fully recover with no residual symptoms within 3 months [44]. However, a small portion of patients experience Persistent Post-Concussive Symptoms (PPCS) lasting more than six months. This sub-set often has co-occurring mental health conditions, such as anxiety, depression, or PTSD, that may delay recovery and require specific treatment. Exposure to a life threatening event (i.e., combat) may pre-dispose individuals to developing acute stress reaction, PTSD, or other mental health disorders.

Post-concussive symptoms are not specific to MTBI. These symptoms occur as part of various conditions, including PTSD, although it should be noted that flashbacks are not a symptom of MTBI, and neurocognitive problems are not a common symptom of PTSD.

PTSD is commonly diagnosed in military populations following combat deployments. PTSD is defined as a stress-related disorder that may develop after an individual experiences a traumatic event, such as threat of death to oneself or to someone else, or damage to one's own or someone else's physical, sexual, or psychological integrity.

It is manifested by frequent re-experiencing of the trauma, through flashbacks or nightmares, avoidance of stimuli associated with the trauma and increased arousal (resulting in sleep problems and irritability) that last longer than 1 month.

Early identification and treatment for PTSD leads to better outcomes. Current scientific evidence supports trauma-focused Cognitive Behavioral Therapy (CBT) and eye movement desensitization reprogramming therapies, and may be supported by medication.

2.7.3 Relevance for NATO

Given the overlap between PTSD and MTBI symptoms, an interdisciplinary team evaluation may be considered an essential component of a comprehensive clinical evaluation for anyone who has PPCS. Knowledge of both diagnoses is critical to ensure appropriate health-care for military personnel.

It should be stressed that the majority of people who sustain a blow or jolt to the head do not develop PTSD. The majority of people who develop PTSD have not sustained a blow or jolt to the head.

Military health-care providers need to be aware of and should consider screening for the presence of PTSD in patients with a history of MTBI who present with persistent symptoms.

Numerous studies are under way to elucidate the neuropathological, neuropsychological, and neurochemical changes that may distinguish between these two military relevant conditions.

Chapter 3 – EPIDEMIOLOGY OF MILITARY MTBI

Karen Schwab, Bryan Garber and Jamie B. Grimes

3.1 BACKGROUND AND INTRODUCTION

Forty-nine countries have been contributing troops to the NATO-ISAF counterinsurgency operations in Afghanistan. ISAF total strength was 100,330 as of 19 February 2013 (see chart for the numbers of troops contributed by each country). Of the Nations contributing troops to the Afghanistan counterinsurgency operation, Canada, France, Germany, Netherlands, Sweden, United Kingdom, and the United States are members of a NATO Task Group, with Canada leading the effort to investigate Mild Traumatic Brain Injury (MTBI) in a Military Operational Setting (NATO HFM-193, RTG). In addition, two of the participating countries have had extensive counterinsurgency experience in Iraq (United States and United Kingdom), and though not a NATO-ISAF operation, the Iraq effort has provided additional experience and evidence on military MTBI acquired in a counterinsurgency operation. The mandate for the working group is to develop "… an international forum for sharing information, research collaboration and establishing best practices for the management of this injury." Significant gaps in knowledge about the "epidemiology, diagnosis, assessment, natural history, relationship to co-morbid problems such as PTSD, optimal management, and the extent to which blast injuries are different from other causes of MTBI" are currently being addressed by researchers in many countries and there has been a rapid evolution of recommendations for management of MTBI. An important outcome of the Task Group members' deliberations is the development of processes to share the rapid accumulation of new evidence and evolving algorithms of care in order to inform policies and practices, as NATO Nations engage in current and future military operations.

This chapter reviews evidence regarding the incidence of MTBI, and outcomes following MTBI, for both blast-related and non-blast-related MTBI. It has become increasingly clear that MTBIs, whether or not associated with explosions, affect cognitive performance and increase symptom burdens immediately after injury. The evidence on whether or not MTBIs affect longer-term outcomes is mixed. Available evidence is sparse regarding chronic outcomes after MTBI in general, particularly for blast-related MTBI acquired in theatre. In light of the sparse evidence regarding blast-related injuries, evidence is reviewed for the acute and chronic outcomes following MTBI in general, and in particular for military populations, in order to provide indicators of what can be expected after blast-related MTBI. As evidence accumulates on blast-related MTBI, it will be possible to better discern similarities and differences in outcomes following blast-related and non-blast-related MTBIs. Earlier neuroradiological studies of patients with MTBI detected brain abnormalities in small percentages of patients. Recent studies using more sensitive techniques, such as Diffusion Tensor Imaging (DTI), have found abnormalities associated with MTBI in more patients compared to control groups. More work remains. Longitudinal studies are needed to determine the long-term associations of brain abnormalities after MTBI, and whether these correlate with underlying cellular pathology, concussive symptoms and cognitive and functional performance [45], [46].

Use of the terms MTBI and concussion are not consistently applied as distinct terms by researchers or clinicians, and for purposes of this paper, they are considered synonymous.

3.2 DEFINITION OF MTBI

In this report, the term Mild Traumatic Brain Injury will be used to include the acute event of blunt impact, acceleration/deceleration movement, and/or forces generated from events such as a blast or explosion [47],

that result in brain injury less severe than moderate or severe TBI (See Chapter 2.2 for a detailed discussion). The criteria generally used to identify severity of traumatic brain injury are the Glasgow Coma Scale (GCS), Post-Traumatic Amnesia (PTA), and loss of consciousness, with MTBIs defined as GCS of 13 – 15, PTA or 24 hours or less, and or Loss Of Consciousness (LOC) of less than 30 minutes. Consistent with commonly used definitions of MTBI, penetrating head injuries and injuries resulting in lesions identified on conventional CT scans are excluded since these are typically categorized as moderate or severe injuries, or complicated MTBIs.

Though TBI severity is a continuum, ranging from very mild to very severe injury [46], measurement tools are too crude to provide a continuous measure of TBI severity. By convention, researchers and clinicians generally use a three category definition of brain injury severity: mild, moderate, and severe. Mild TBI is by far the most common severity level of TBI, even among hospitalized patients. However, its definition, diagnosis, and determination of long-term outcomes remain elusive and controversial.

Three of the NATO Nations in the Task Group (the US, UK and Canada) have adopted the 2009 VA/DoD Evidence-Based Practise definition of MTBI [5], while a third (United Kingdom) has modified the definition to exclude dazed/confused and seeing stars as part of the definition of MTBI. (See Ruff et al., 2009 for a description of the difficulties of including "dazed" as a definer of MTBI) [48].

> *Mild TBI in military operational settings is defined as an injury to the brain resulting from an external force and/or acceleration/deceleration mechanism from an event such as a blast, fall, direct impact, or motor vehicle accident which causes an alteration in mental status typically resulting in the temporally related onset of symptoms such as: headache, nausea, vomiting, dizziness/balance problems, fatigue, insomnia/sleep disturbances, drowsiness, sensitivity to light/noise, blurred vision, difficulty remembering, and/or difficulty concentrating.* [5].

The VA/DoD definition includes (LOC), post-traumatic amnesia or retrograde amnesia (PTA or RGA), or being dazed or confused. The definition was adapted from other existing definitions developed in clinical and sports settings including the American College of Rehabilitation Medicine [49]; the Centers for Disease Control and Prevention [50], [51]; the World Health Organization Task Force on MTBI [15]; the National Athletic Trainers' Association [9]; and, the Prague Sports Concussion Guidelines [10].

The use of an agreed-upon definition of MTBI (whether the above definition or another) would allow NATO Nations to extrapolate research findings into their clinical settings and permit more consistent algorithms of evaluation and treatment in member clinics. However, applying a *definition* of MTBI *into clinical diagnoses* weeks or months post-injury is challenging. Alterations of consciousness, particularly being dazed or confused, can also occur with "psychologically induced confusion" [48]. Without gold standard biomarkers for either TBI or the anxiety disorders that frequently co-occur in individuals serving in theatre, diagnosis often depends upon unconfirmed self-reports. Careful clinical interviews are currently the best available approach to establishing diagnosis. Gathering witness accounts [52] and documenting injury events in theatre [53] are methods that are potentially available to strengthen confidence in MTBI diagnosis.

3.3 BLAST-RELATED MTBI: INCIDENCE; ACUTE SEQUELAE; CHRONIC SEQUELAE

MTBI due to blasts: MTBI has received considerable attention during current military engagements in Iraq and Afghanistan. In part, this is due to the extensive use of explosions as a weapon in Afghanistan and Iraq [54] with resultant concern about the vulnerability of troops to acute and chronic effects of blast-related MTBI,

and whether vulnerability for injury increases with exposure to multiple explosions, and partly because of accumulating evidence of the acute effects of MTBI in sports populations, particularly evidence on short-term cognitive declines after MTBI. Blast-induced injuries have been primarily combat-related, but civilian populations are at risk as well. It is estimated that blast-related injuries increased "eight-fold" between 1999 to 2006 worldwide, as militant and extremist groups increasingly targeted civilians as well as active duty military [55].

Explosive injuries are generally multi-modal. That is, service members with MTBIs caused by explosions usually suffer simultaneous associated injuries caused by the explosion, such as falls, impact from falling objects, and/or motor vehicular accidents. The term "blast-related MTBI" indicates that outcomes and the course of recovery after such injuries are due to the "package" of injuries, and not just to TBI alone.

3.3.1 Incidence of Blast-Related MTBI

Blast-related MTBIs are frequent injuries in NATO counterinsurgency operations in Afghanistan, in Operation Iraqi Freedom (OIF) and in Operation Enduring Freedom (OEF). Incidence estimates vary depending upon whether the service members were hospitalized or not hospitalized, and whether the service members had sustained injuries or were part of a wider military population who had served in OIF/OEF. Blast-related injuries accounted for 68% of 433 US casualties from the OIF/OEF treated at Walter Reed Army Medical Center from 2003 to April, 2005; 89% of this patient series had closed-head injuries [56]. Kennedy et al. [57] described a series of 377 consecutive service members medically evacuated to Camp Bastion Role III Combat Hospital in Afghanistan for mandatory evaluation of concussion (within 50 m of a blast, in a vehicle accident/rollover or struck in the head; DoD 2010) – 91% met criteria for concussion. Of those determined to have been concussed (n = 343), all but 22 were due to blasts. The incidence of blast-related MTBI in non-hospitalized samples is smaller but still concerning. In a study of troops in a brigade combat team (N = 3,973) returning to Fort Carson after a year-long deployment, 22.8% of service members had at least one MTBI confirmed by clinician interview after return from theatre, and 88% of these were blast-related [58].

3.3.2 Neuroimaging

Mapping the neuropathology of blast-related MTBIs acutely and as it develops over time has become possible with the development of newer imaging techniques such as Diffusion Tensor Imaging (DTI) and functional imaging techniques. Although CT scanning studies have detected some abnormalities in individuals with MTBI, the majority of individuals were shown to be normal [59]. Please note that definitions of MTBI generally exclude individuals with abnormalities on CT. DTI is more sensitive to diffuse axonal injury and small haemorrhages believed to represent the pathology associated with MTBI, and has detected more abnormality in these patients (see [45], [46], [60] for reviews of evolving neuroimaging techniques and findings with MTBI). Microscopic diffuse axonal injury detected with DTI has been reported in patients acutely injured with blast-related MTBI [61]-[64], but studies do not consistently detect DTI abnormalities in patients with more chronic injuries, i.e., those of 6 months or longer [63], [65]. MacDonald et al. [64], utilizing DTI, detected abnormalities consistent with axonal injury in a group of 63 military personnel with acute blast-related MTBI (18 of 63), as well as at the 6 to 12 month follow-up examinations. Blast-exposed service members without TBI (n = 21) did not evidence the same pattern of abnormalities. Not all blast-related MTBI patients in the series showed evidence of axonal injury. Levin et al. [65], on the other hand, did not detect neural abnormalities in veterans studied with DTI more than 2 years after injury when compared to veterans without blast exposure or TBI [63]. None of the patients studied in these neuroimaging studies had suffered a pure or primary blast injury, leading to questions about whether or not the microscopic diffuse axonal injury detected was due to blast TBI or to associated injuries. Primary blast injuries are rarely seen in clinical settings, making it difficult to determine the

independent effects of blast MTBI. However, one case study of a service member with MTBI resulted from primary blast wave alone, which provides some evidence that blasts can cause MTBI [66].

Neuroradiological studies of this victim of primary blast wave found patterns of axonal injuries, suggesting that primary blast wave may account for the injuries detected in the larger studies.

3.3.3 Sequelae of Blast-Related MTBI

The evidence regarding post-concussive symptoms for service members with blast-related MTBIs is mixed. Blast-related MTBIs were found to be associated with persistent post-concussive symptoms (surveyed 3 – 6 months after deployment to Iraq) for service members with loss of consciousness (n = 201), but not for service members with milder forms of MTBI (i.e., alteration of consciousness without loss of consciousness) (n = 373) [67]. Cooper et al. [68] conducted reviews of the clinical evaluations of service members in acute treatment. They found that service members with burn injuries secondary to explosions with clinically diagnosed MTBI (n = 50) had significant but small cognitive functioning impairments measured with the Repeatable Battery for the Assessment of Neuropsychological Status (RBANS) when compared to service members with explosion burn injuries without MTBI (n = 117). These findings were still significant when psychiatric diagnosis, time since injury, pain medications, and trauma severity were controlled in hierarchal linear regression. Psychiatric co-morbidity did not affect cognitive functioning. Kennedy and colleagues [69] used retrospective research chart reviews to compare PTSD symptoms in service members with blast-related MTBI incurred during OIF/OEF, and service members with non-blast-related TBI who had also served in OIF/OEF. They found that blast-related MTBI was associated with more re-experienced symptoms than non-blast-related MTBI. However, the two groups of MTBI service members (586 blast-related MTBI patients and 138 with non-blast MTBI) did not differ on other PTSD clusters nor on total PTSD scores. The same research team [70] also evaluated the relationship of self-reported symptoms and the presence of other injuries in 274 service members with blast-related MTBI. They found that service members with blast-related MTBI who also had other associated injuries reported *fewer* stress and neurobehavioural symptoms than service members without other injuries. They speculate that having an invisible wound such as MTBI creates ambiguity regarding the expected course of recovery and that the presence of other injuries and rehabilitation for those injuries provides measureable progress towards recovery.

Kontos et al. [71] found a dose-response relationship between number of blast-blunt MTBI, and both MTBI and clinical levels of PTSD symptoms in their retrospective chart review of 22,203 US Army Special Operations Command personnel who completed ImPact, Post-Concussion Symptom Scale (PCSS), and PTSD Checklist (PCL) between November 2009 and December 2011 – 13% had a diagnosis of 1 or more MTBIs. An effect upon cognitive impairment was less pronounced and was limited to reaction time. Some studies of cognitive performance have reported no differences or small differences between service members with blast-related MTBI and those with other MTBI. An in-theatre study comparing blast-related and non-blast MTBIs immediately after injury (within 72 hours) found few differences between service members with these two types of MTBIs (i.e., similar on concussive symptoms, psychological symptoms, and neurocognitive testing). Both MTBI groups had impaired cognitive reaction time acutely after injury [72]. Brenner and colleagues [73] compared patients with blast-related MTBIs to patients with other MTBIs injured several months previously. They did not detect any remaining cognitive problems in either patient group on neuropsychological testing. Similarly, Lange et al. [74] comparing 21 non-blast MTBI and 35 blast-related MTBI sustained in OIF/OEF found that after controlling for depression and stress, performance on neurocognitive measures was similar between the two groups.

One approach to determining the effect of pure blast wave upon human subjects has been the carefully controlled studies of military subjects in training to become breachers in the US and Australia. Breachers are trained to use

explosions to enter enemy controlled spaces. Preliminary reports indicate that multiple blast exposures in these military trainees have not been associated with findings in neuroradiological assessments or neuropsychological testing. However, *instructors* in these programs showed evidence of more neurological impairment than would have been expected in unexposed populations [75]. A pilot analysis comparing reaction times, neurocognitive performance, and self-reported symptoms for breachers in New Zealand in a two-week training course found significant differences between those with the highest (n = 5) and lowest (n = 5) biomarker composite scores out of the 21 subjects [76]. These findings suggest brain perturbation linked to exposure to low-level blasts in breacher training and are being further investigated.

3.3.4 Chronic Sequelae of Blast-Related MTBI

Systematic studies of chronic outcomes of blast-related MTBI in the published literature are sparse. Schneiderman et al. [25] found that in patients observed following more than 5 months from returning from deployment to Iraq, blast-related MTBIs compared to non-blast MTBIs did not differ regarding persistent symptoms. Heltemes et al. [77] found differences when they examined self-rated health for service members identified in the Expeditionary Medical Encounter Database records, with blast-related MTBI versus those with other mild injuries. Service members with MTBI were 5 times more likely to report a major negative change in self-rating at 6 months post-injury compared to pre-deployment, when controlling for age, rank, branch of service, Injury Severity Score, mental health diagnosis prior to injury, and referral to a health care professional.

3.4 MTBI IN MILITARY AND CIVILIAN POPULATIONS

3.4.1 Methods of Estimation

Incidence of civilian MTBI has been estimated with one of two approaches:

- Counting MTBIs among individuals receiving medical treatment; and
- Counting self-reported MTBIs in surveys.

Both of these methods have acknowledged limitations and biases. Several studies have documented substantial inaccuracies in incidence estimates derived from using medical charts. These counts result in substantial under- *and* over-counts of MTBIs in medically treated populations [78]-[80]. For instance, Bazarian et al. [80] found that 46% of patients who had MTBIs (determined using a comprehensive research interview; n = 516) did not receive an MTBI diagnosis code. In the same study, only 24% of patients assigned an ICD-9 diagnosis code consistent with MTBI (n = 1000) were found in the research interview to have had an MTBI. Another source of undercount when medical records are used to estimate the incidence of MTBI is that many individuals with MTBI do not seek care from medical providers. In a national survey, Sosin et al. [81] found that a quarter of individuals reporting loss of consciousness due to injury reported they had not received medical care for their injury. Individuals with milder forms of MTBI (i.e., no loss of consciousness) are less likely to present for medical treatment than individuals with loss of consciousness, so the undercount is undoubtedly higher than the 25% found in the survey.

Surveys asking individuals to self-report symptoms and signs of MTBI capture non-medically attended and medically attended MTBIs. Though self-reports potentially generate a fuller count of MTBIs, they have their own biases as they depend upon accurate recall as well as subjects' correct interpretation of the questions used in the surveys. Inaccuracies have been identified in respondent placement of injuries within the time period queried in surveys, and in their reports of symptom levels prior to injury [82], [83]. Incidence estimates in military populations have similar challenges to those produced for civilian populations, along with several unique challenges. The two approaches to developing incidence estimates in military populations mirror those of the

civilian population: databases that capture medically treated individuals, and self-reported injuries captured in studies and screening programs. The military databases of medically treated individuals are centralized in the US and Canada, and include all military treatment facilities, which is an advantage over civilian databases. Nevertheless, military databases undoubtedly miss some MTBIs and have incorrect coding, as in civilian databases. Adding to these issues, during combat, service members may delay seeking immediate treatment in order to continue missions. Additionally, troops may be encouraged to "shake it off" and continue the fight, thereby discouraging reporting for treatment.

The US Military and Department of Veterans Affairs (DVA) have instituted widespread TBI and PTSD screening of service members and veterans who have served in OIF/OEF, in order to permit returning service members to self-report ongoing symptoms and problems that trigger medical evaluations, and, when needed, referrals for care. One small study found that self-reported probable TBI in screens corresponded with unblinded clinical interviews [84]. Screening protocols in both the DoD and DVA now require positive answers to all four questions on the TBI screens, adding symptoms at the time of injury and at time of screen to injury event, and alteration of consciousness questions. The additional questions permit the systems of care to focus on symptomatic individuals, but exclude some MTBIs. Terrio et al. [52] found better association between the DoD screening tool for MTBI and the clinician confirmed diagnosis when questions 1 and 2 only were used to calculate a positive TBI screen rather than all 4 questions on the screening tool. In contrast, a large study conducted in several US Veterans' medical centres and one VA out-patient clinic found good test-retest reliability (0.80), high sensitivity (0.94), and moderate specificity (0.59) when the VA TBI screening tool was compared to a structured diagnostic interview for TBI [85].

In response to these challenges and because MTBIs are often self-reported months after exposure when service members return from OIF/OEF, a third approach to the identification of service members with MTBI has been developed by the military in the US and the Netherlands. The US instituted mandatory investigations in theatre (Directive-Type Memorandum (DTM) 09-033) on 21 June 2010 for the identification of US Service Members involved in potentially concussive events, known as event-based reports. The Netherlands has utilized similar procedures. Investigations involve direct evaluations of exposed service members, rather than relying upon self-reported information provided months after the injury event. Data gathered thus far is not available to clinicians or researchers. However, this data is a potential gold standard for MTBI identification in the military.

3.4.2 Incidence Estimates

Cassidy et al. [86] critically reviewed 121 studies of civilian MTBI that met their criteria. Definitions of MTBI varied substantially across these studies, and prevented the authors from precisely estimating an overall incidence rate. Estimated incidence rates varied from 51 to 782 per 100,000 persons, depending upon the definition of MTBI used in a study, and the population sampled. After evaluating the evidence, they estimated the true population incidence rate to be greater than 600 per 100,000 persons. Evidence consistently indicated that the incidence of MTBI treated in hospitals or ERs was far more common than moderate or severe TBI, and that men experience twice the risk of MTBI than women.

Trends: The worldwide incidence of civilian TBI is increasing due to increased motor vehicle use in poorer countries. The World Health Organization projects TBI will surpass many diseases by 2020 as the major source of death and disability [87]. In the US, the trend over the past 20 years or so has been for MTBI to be treated increasingly outside of hospitals, which means that surveillance systems have had to include out-patient treatment as well as hospital treatment in order to capture treated MTBI. These incidence rates do not include military populations, though there have been recent calls for inclusion of military populations given the large numbers of service members MTBIs returning from OIF/OEF.

Military MTBI is inconsistently tracked across NATO Nations. Of the countries with membership in the NATO Task Group, the US, UK, and Canada maintain more systematic data capture systems; Sweden, and France have not yet developed systematic approaches for developing TBI incidence reports during military engagements. The Netherlands conducted an extensive research program to determine the incidence of MTBI during NATO engagement in Afghanistan.

The US reports higher rates of MTBI than average, and the UK and Canada report lower rates [88], [89] However, length of deployments explained part of the difference between US and UK incidence rates of MTBI [88], [89]:

Canada: MTBI was reported in 117 of 1,817 respondents (6.4%) surveyed. 74 (4.1%) of these reported an injury with being dazed/confused only.

United Kingdom: 17 service personnel were treated on the MTBI four level programme as a result of deployment in Iraq, of which 15 were aeromed patients out of theatre. 331 service personnel were treated on the MTBI four level programme as a result of deployment to Afghanistan, of which 320 were aeromed patients out of theatre to receive treatment (although note that the aeromed was not specifically for the suspected MTBI).

Sweden: Sweden has no regular screening for MTBI, although it is hoped that the system for detecting and reporting injuries will be improved.

France: Is in process of summarizing its MTBI in-theatre experience.

Netherlands: Started screening all soldiers in theatre after blast exposure within 25 metres from the blast from November 2009. One hundred cases were assessed, and followed up. Few cases were identified as persistent post-concussive symptoms based on self-report. A discrepant higher number was identified with persistent neurocognitive decrements. This is followed-up for research purpose.

United States: Findings of in-theatre medical encounters: In-theatre medical encounters recorded in the Blast Exposure and Concussion Incident Report (BECIR) indicate 2260 MTBI cases in the period from August 2010 through December 2013 in Afghanistan, and 333 MTBI cases for the same period in Iraq. The codes are based upon ICD codes defined as MTBI. These encounters capture higher level care more thoroughly than lower level medical care (such as medic only encounters). (Source: Armed Forces Health Surveillance Center).

The US Military and the Department of Veterans Affairs (DVA) have instituted widespread TBI and PTSD screening of service members and veterans who have served in OIF/OEF in order to permit returning service members to self- report ongoing symptoms and problems which then lead to further evaluations for and referrals for care of those with continuing problems and symptoms. Self-reported probable OIF/OEF MTBI is captured at return from deployment (Post-Deployment Health Assessment). 3% of returning service members from active components of the services, and 3% from reserve/guard components screened positive for MTBI – (affirmative TBI screen defined as a response of ‘yes’ to at least one response option in all four of the TBI questions – (Source: Armed Forces Health Surveillance Center):

a) Experiencing an event;

b) Having symptoms immediately following the event;

c) Had problems after the event; and

d) Still have problems in the past week.)

During peacetime, Ommaya et al. [90] estimated the incidence of military TBI treated in hospitals in 1992 to be 1.57 times higher for males and 2.54 times higher for active duty females than for age-adjusted civilians (dependents, retirees, and dependents of retirees). However, US Army hospital admissions for all TBI decreased through the 1990s, with MTBI rates decreasing more than for more severe TBIs [91]. By the end of the 1990s, most of the Army's hospitalization rates were lower than for civilian hospitalization rates. This was thought to be due to effective injury prevention programs in the military and to changes in the Army population over the time period, and changes in hospital admission patterns [91].

The rate of physician-diagnosed MTBI within the US military population increased during wartime between 1997 and 2007 [92], [93] with the largest increases seen in the last two years of the period [93]. Among individuals serving in Iraq, there was a 38.4% annual increase of new cases [93].

Polusny [23] found that rates of self-reported MTBI and PTSD increased between surveys in Iraq 1 month before returning home and at 1 year follow-ups in a large sample of US National Guard soldiers. This interesting finding suggests that estimates of MTBI and PTSD, when derived from self-reports, vary depending upon the time post-injury of surveys [23]. In fact, Rona et al. [88] argues that self-reported injury obtained post-deployment should be reported as prevalence estimates instead of incidence estimates. Rona's argument is particularly valid when current post-concussive symptoms are included as part of the definition of MTBI, as is the case in the US military and DVA screenings.

In order to compare wounding patterns in OIF/OEF with earlier conflicts, it is necessary to use the historical category, "Head and Neck wounds". Medical treatment of wounds in the head and neck body region includes all TBI severities (mild, moderate, and severe), injuries of the face, cervical spine, and neck superior to the clavicles. Owens et al. [94] utilized the Joint Theater Trauma Registry data collected in OIF/OEF from October 2001 through January 2005 to develop counts of medically treated wounds in this body region and compared these to other major US military engagements. They reported that the percentage of combat injuries in the head and neck body region were greater in OIF/OEF (30%) than during previous conflicts. Among medically treated wounds in WWII, 21% were in the head and neck body region, nearly identical to the percentage in Korea (21.4%). During Vietnam, 16% of treated combat wounds were in the head and neck region. A review of British servicemen found that head, face, and neck injuries accounted for 18% of battle injuries in 2006, 28% in 2007, and 23% in 2008; explosions were the primary cause of these injuries [95].

The increased number of medically treated head and neck wounds has been attributed to various causes, including improvements in body armour and increased use of IEDs [95]. Additionally, improved awareness and tools for the identification and evaluation of MTBI must be considered a contributing factor.

3.5 ACUTE SEQUELAE

Acute sequelae associated with MTBI have been measured in numerous studies, documenting both self-reported symptoms and neuropsychological impairments following MTBI acutely after injury. In a critical review of symptom recovery and neuropsychological test performance in adults with MTBI, Carroll et al. [15] found that subjects injured while participating in sports commonly experienced symptoms immediately after concussion. Symptoms included headache, blurred vision, dizziness, self-perceived memory problems and confusion. Other adults with non-sports-related MTBI reported similar symptoms after injury, including headache, fatigue, forgetfulness and sleep difficulties. Though such symptoms are not specific to MTBI, studies have found "… they are more common within the first month after MTBI than after other injuries or in the general population." Their review of cognitive sequelae measured with neuropsychological assessments likewise found evidence for acute effects of MTBI. Studies accepted in their review found consistent evidence of "… cognitive

deficits within the first few days after the injury, including problems of recall of material, speed of information processing and attention. Resolution of symptoms and return to normal levels of cognitive functioning generally occurred within 3 to 12 months after injury, with *cognitive deficits* associated with MTBI generally resolving within 3 months." The authors recommended that future investigations include control groups and additional variables to measure confounding factors such as pain, prior TBI, other injuries, post-injury events, and distress, in order to provide improved evidence on these issues.

Studies of the acute consequences of MTBI conducted after the review by Carroll et al. [15] have confirmed frequent symptom reporting and problems of cognitive performance in the days and weeks following MTBI. Several of these studies have included analyses of possible confounding variables, comparisons with injury control groups, or included neuroimaging in order to further evaluate the meaning of symptoms and their clinical implications.

Emergency department patients with MTBI (n = 246) were found to have poorer cognitive scores on learning and memory, orientation, and speed of information processing tested within 24 hours of injury than patients with orthopaedic injuries (n = 102) [96]. Ponsford et al. [97] found that subjects with MTBI treated in the Emergency Department (ED) (n = 123) more often had post-concussive symptoms, and impaired cognitive functioning in the emergency department and at 1 week post-injury than did a matched control group treated for general trauma (n = 100). Kashluba and colleagues [98] compared MTBI patients treated in 2 emergency departments with matched controls within 1 month of injury and then again at 3 months. They found that symptom complaints were common for the MTBI patients at 1 month, but that by 3 months their complaints had diminished. MTBI patients continued to endorse only 3 of the 43 symptoms by 3-month follow-up ("doing things slowly," "fatiguing quickly," and "poor balance") as measured with a Bonferroni corrected effect size. However, MTBI patients reported higher severity levels of symptoms than did the controls (on 10 of the 43 symptoms). In contrast, Meares et al. [17] found that post-concussion syndrome was not specific to MTBI compared to non-brain-injured trauma among patients treated in a level 1 trauma hospital within 14 days of injury (n = 90 patients with MTBI; 85 trauma controls). Ponsford et al. [97] suggest that measures of symptomatology based upon ICD-10 criteria of post-concussive disorder such as Meares' study, include a more limited set of the symptoms that can be experienced by patients with MTBI than were included in their study, and that this difference may explain the difference between Meares' findings and other studies. Multiple MTBIs have been linked to greater symptomatology in retired football players [99], and in active duty service members [100]. Guskiewicz and colleagues used surveys of retired professional football players to determine the relationship of mild cognitive impairment and memory problems with multiple concussions. They found that retired players with three or more concussions were associated with clinically diagnosed mild cognitive impairment and self-reported significant memory impairments compared to retired players without a history of concussion [101].

Studies have reported inconsistent evidence of associations between symptoms after MTBI and neuro-imaging. DeGuise and colleagues [102] compared MTBI patients with (n = 45) and without findings (n = 176) on cerebral imaging (using CT) at two weeks post-injury. Those with imaging findings more often showed auditory and vestibular system dysfunction; surprisingly, uncomplicated MTBI patients (those without cerebral imaging findings) reported more severe post-concussive symptoms than patients with cerebral imaging findings. Lange et al. [103] found that MTBI patients (n = 60) reported more post-concussive symptoms than trauma controls (n = 34), but they did not find a relationship between Diffusion Tensor Imaging (DTI) and ICD-10 post-concussive disorder. Using DTI, Henry et al. [104] found white matter differences between concussed athletes (n = 18) compared to non-concussed athletes (n = 10). They did not find that the number of regions showing alterations was associated with the number of symptoms reported, but number of regions altered was associated significantly with the number of concussions reported (3 concussions versus 1 or 2). Gosselin et al. [105] reported that compared to controls, symptomatic MTBI patients had more findings on functional magnetic

resonance imaging (fMRI) and Event-Related Potentials (ERP) months after injury (5.7 plus/minus 2.9 months post-injury). (n = 14 mTBI patients; 23 controls).

As with civilian populations, military populations with MTBI have, on average, more symptom complaints, and poorer cognitive performance when studied in the acute period after MTBI (generally defined as within 3 months of injury). For instance, this result was observed by Bryan and Hernandez [106] in an in-theatre study (N = 116), that compared patients with and without MTBI who were referred for a TBI evaluation a median of 2 days post-injury. Patients with TBI demonstrated greater declines across all sub-tests (ANAM) on several throughput scores (Simple Reaction Time, Procedural Reaction Time, Code Substitution-Learning, and Spatial Memory scores) than non-TBI patients when post-injury scores were compared to pre-deployment ANAM scores. Patients did not differ on accuracy scores, Code-Substitution Delayed, or Mathematical processing scores. Coldren et al. [107] also conducted a comparison of ANAM scores for patients with MTBI compared to non-concussed military subjects. They obtained pre-deployment ANAM scores for a sub-set of participants, and repeated ANAM testing at 5 or more days after injury. As with the Bryan and Hernandez study, Coldren et al. found significant differences in cognitive scores between concussed and non-concussed subjects immediately after injury (within 72 hours). They did not find differences at five or more day's follow-up, suggesting that ANAM scores return to within normal levels within 5 to 10 days in the combat setting. The recovery of cognitive function is consistent with the sports literature [107]. Caution needs to be used when testing cognitive performance, since poor effort has been measured in some returning service members [103], [108], similarly caution that symptom validity needs to be part of the evaluation of symptoms after MTBI.

Three or more concussive symptoms were recalled by soldiers to have occurred immediately post-injury in a large cohort drawn from an Army unit that served in Iraq. Headache and dizziness were most frequently reported post-injury. Soldiers injured without TBI reported fewer of these symptoms post-injury (33% of soldiers with TBI reported 3 or more symptoms immediately post-injury compared to 3% of injured soldiers without TBI) [58]. Headache in MTBI patients presenting to a combat support hospital in Iraq were found to be associated with insomnia, loss of consciousness, PTSD symptoms, and slowed reaction time [109].

3.6 LONG-TERM SEQUELAE

If symptoms and problems following MTBI persist for months or years and are attributable to MTBI, it would imply different treatment and evaluation strategies than if these problems resolved within weeks or months, or are explained by other, independent events or patient characteristics. Long-term consequences of MTBI identified in prior studies may be explained, at least in part, by other, often unmeasured factors such as pain and associated injuries. The risks of long-term sequelae after MTBI are thought to be greater with multiple MTBIs, MTBIs received before recovery is complete, MTBIs with overlapping PTSD or anxiety, pain, incentives for exaggerated symptom reporting, depression, and MTBIs resulting from close exposure to blasts. Research is ongoing and more evidence is expected in the near future.

Early cross-sectional studies suggested that as many as 10 – 20 % of individuals reporting previous MTBI continued to have "persistent physical, emotional, and cognitive symptoms" months or years after injury [110]. But, a number of investigators have questioned the existence of persistent symptoms due to MTBI or thought that the estimated percentage was too high, and suggested that base rates of these symptoms in non-injured populations, other patient characteristics, or subsequent injuries might explain the findings. Factors other than the MTBI itself were found in studies reviewed by Carroll et al. [15] as explaining or partly explaining persistent symptoms, including female gender, other injuries, prior brain illness, prior head injuries, psychiatric problems, pain, older age, acute stress disorder, ongoing litigation, and PTSD. However, other than PTSD and ongoing

litigation, there was not enough consistency in the predictors studied or findings to conclude which factors contributed to persistent symptoms.

Because of alternate explanations for persistent symptoms in MTBI populations, researchers have increasingly used prospective studies with longitudinal follow-up and/or included control groups to investigate the association of persistent symptoms and MTBIs. Prospective longitudinal follow-up studies permit a closer link between the injury event and outcomes than do cross-sectional studies. Carefully designed control groups permit the comparison of outcomes between injured and non-injured subjects who are presumed to be comparable on other characteristics (measured and unmeasured). For example, in the study summarized above, Ponsford et al. [97] followed subjects for 3 months post-injury. Though the MTBI patients reported more symptoms early on than did the trauma control group, by 3 months post-injury, both injury groups had improved and did not significantly differ on any symptoms. There were also no differences in median pain scores, and both groups had similarly high return to work rates by 3 months. However, the MTBI group had poorer mean scores on the General Health, Vitality, and Mental Health components of the SF-36 Health-related quality of life. Additionally, the MTBI group had more ongoing impairment at 3 months on one of the subtests of the ImPact cognitive test (the Visual Memory subtest, which the researchers rate as the sub-test requiring the most mental effort), and more often reported problems with concentration and memory than did controls at 3 months. Their findings are similar to several other studies that found evidence of improvements in symptoms over time, but with persistent symptoms in MTBI patients continued relative to trauma controls at 3 months [111], at 6 months [112] and 3 and 12 months post-injury [113]. Compared to reports of headache in other populations, TBI patients undergoing rehabilitation in the Model Systems Study reported frequent headaches more often through the first year following injury [114]. Masson et al. [115] included subjects with MTBI in their population study in Aquitaine, France, and found that mild TBI subjects did not differ from moderate or severe TBI subjects in their complaints of headache, memory problems, anxiety, or sleep disturbance. All TBI subjects were more likely to report those complaints than control subjects (i.e., subjects with lower-limb injury). Selassie and colleagues found that among patients hospitalized with TBI, long term disability determined at the 12-month follow-up was associated with TBI severity, but was associated for patients with mild TBI (i.e., no LOC, no intracranial injury) [116].

Neuropsychological Testing: In general, neuropsychological evaluations find cognitive impairments in the acute period after MTBI, and these generally resolve within days to months of injury. A few studies have found some continued neuropsychological differences between MTBI patients and controls, but generally the differences are small and/or isolated to a few sub-tests. In contrast, a larger percentage of MTBI patients *self-report* problems with cognition. Studies have found that self-reported cognitive problems were not associated with neuropsychological test performance at 6 months post-injury for MTBI patients [117], [118]. Stulemeijer et al. identified poor effort as a contributing factor to poor scores on neuropsychological assessment at 6 months post-injury in these subjects [119].

Studies of the Chronic Effects of MTBI in Military Populations: Veterans of combat in OIF/OEF who screened positive for TBI in a Veterans Affairs Medical Center were found to have higher rates of neurological deficits (most commonly impaired olfaction) and PTSD with the greater the number of MTBI exposures with LOC [120]. Service members compared on self-rated health pre- and post-deployment to Iraq (i.e., "Overall, how would you rate your health during the past month?") who had experienced blast-related injuries reported poorer health at 6 months post-injury. Those with MTBI were 5 times more likely than service members with other mild injuries to report a major negative change in their health [77]. Canadian military personnel with probable MTBI were more likely to have poorer physical health than military personnel with negative MTBI screens [121]. Alcohol abuse was slightly higher in combat injured service members with MTBI than in-service members with other injuries (6.1% vs. 4.9%; total n = 3,123). However, MTBI was not associated with alcohol

abuse in a multivariate analysis [122]. Various co-occurring conditions, including combat stress [68] are associated with increased concussive symptoms reporting in service members with MTBI.

The overlap of MTBI and PTSD has been identified in military populations [12], but also occurs in some civilian injured populations. Determining whether chronic problems are due to physical or psychological injury is challenging with available diagnostic tools. Jones, Fear and Wessely [13] remind us that the issue of determining the cause of shell-shock in World War I and II has parallels with the current debate over the causes of chronic symptoms in today's returning service members. They conclude that "… a clear-cut distinction between physical and psychological injury is unlikely to be realized, not least because the two co-exist."

Charles Hoge and colleagues [22] investigated the effects of MTBI, PTSD, and depression on persistent MTBI symptoms in a sample of National Guard troops who had returned from service in Iraq, 3 – 4 months before the survey. After controlling for PTSD and depression in multivariate statistical analysis, they found that symptoms typically attributed to MTBI were no longer significantly related to MTBI. Only headache remained significantly associated with MTBI, once PTSD and depression were controlled. Various pathophysiology links and endocrine factors may help to explain the vulnerability of some injured service members. Several reviews of the literature have examined the overlapping symptomatology, various interpretations for the findings, and implications for clinical care [123]-[125]. Lack of gold standard measures to validly identify un-witnessed and/or distant MTBI presents a methodological challenge to the differential diagnosis of the two conditions in service members returning from deployment. Much of the data gathered thus far on the effects of MTBI, other types of injuries and associated conditions such as anxiety and PTSD upon chronic outcomes have come from cross-sectional studies that are subject to alternative explanations. Carefully designed longitudinal studies with appropriate control groups that are currently in process will assist in sorting out the validity of various competing hypotheses. Various explanations have been proposed for chronic symptoms in a percentage of service members with MTBI, including PTSD [12], pain, grief [126] the presence of prior symptoms, and prior depression.

3.6.1 Military TBI Prevalence

Several long-term studies of military populations have included subjects with MTBI. Finnish war veterans of 1939 – 1945 with MTBIs followed in 1966 as part of a larger longitudinal study of veterans with TBI appeared to be more likely to have suffered schizophrenic psychosis than more severely injured veterans with TBI [127]. The Vietnam Experience Study conducted multi-dimensional health assessments of US veterans about 16 years after discharge. Veterans who self-reported a history of MTBI (not necessarily during their war service) were found in health assessments to be more likely to have post-concussive symptoms, depression, anti-social personality disorder, visual problems, and impaired tandem gait than veterans denying TBI [128].

Several studies have examined the prevalence of symptoms associated with MTBI in military and veteran populations with recent wartime experience. Within the US Department of Health Affairs, all patients who served in OIF/OEF are required to receive TBI screening to determine if they had possible TBIs while in theatre. 90% were offered TBI screens and 17% screened positive for possible MTBI. About half of the veterans who screened positive for MTBI had appointments subsequent to screening in TBI/Polytrauma specialty clinics [129]. In one study, 4620 UK personnel deployed to Iraq or Afghanistan completed a questionnaire between 2007 and 2009. The study found that length of deployment was associated with MTBI and helped explain previously reported differences between US and UK rates of MTBI in returning personnel (except for adjusted multiple physical symptoms) [89]. Post-Deployment Health Assessments at Fort Carson (sample of 3973 from one Brigade Combat Team) found that MTBI and PTSD screens were both independently associated with post-concussive symptoms [73]. In a sample of OEF/OIF veterans completing a Veterans Needs Assessment Survey,

18.8% screened positive for MTBI. Those screening positive were younger, more often had PTSD, reported fair/poor overall health and unmet medical and psychological needs, and scored higher on measures of psychosocial difficulties and perceived barriers to mental healthcare. Injuries involving LOC were associated with greater work-related difficulties and unmet psychological needs. PTSD mediated the relationship between MTBI and all of these outcomes [130].

Vermetten et al. [131] studied non-medically evacuated Dutch soldiers exposed to the effects of blast from IED or grenades (i.e., within 25 meters of proximity). Assessments included the MACE performed within 24 – 48 hours of exposure by a specially trained nurse or doctor (baseline), neuropsychological tests, and clinical assessments at two follow-ups (first follow-up within three to six months after their return home, and second follow-up at 12 months). Preliminary findings have been reported on the MACE findings for 98 soldiers and first follow-ups on 56 soldiers. Of the 98 soldiers administered the MACE at baseline, two soldiers experienced loss of consciousness for a few minutes (in one soldier accompanied by retrograde and anterograde amnesia). Symptoms reported by the 98 soldiers on the MACE included: anxiety (42%), headache (34%), and pain in the locomotor system (27%). Three soldiers had neurological abnormalities recorded in the neurological screen (1 had eye-tracking problems, mild word finding problems, and vestibular problems; 2 had problems with eye tracking and word finding). At follow-up, a "significant portion of the studied population" had a very weak performance on information processing and memory tests. 39 of the 56 soldiers scored below low average on at least one of the neuropsychological sub-tasks. However, the researchers point out that they did not have pre-deployment cognitive performance scores, and cannot rule out pre-injury scores as explaining those results.

3.6.2 The NATO Experience

There is limited evidence on the short-term and chronic effects of military MTBI, especially from blasts. Additional studies are scheduled for completion in 2013 and later. Given gaps in evidence on the effects of military MTBI, NATO Nations have developed various policies regarding the identification, evaluation, and treatment of service members with these injuries. Several countries participating in the NATO Task Group on Mild Traumatic Brain Injury have developed standardized approaches to the screening and evaluation of service members who sustain potential MTBIs. Other participating countries have been mindful of such injuries, but have not adopted standardized approaches to their identification and/or treatment, rather permitting clinicians to develop individualized treatments for service members presenting with such injuries. Efforts to reduce morbidity due to MTBI have included post-deployment TBI screening, in-theatre medical evaluations at the time of the event, follow-up assessments, and training of providers and medics on the identification of service members with MTBI. Not all countries employ all these approaches. There is little consensus across the 6 countries participating in the Task Group about the cost/benefit ratio of screening, or the validity of current definitions of MTBI. Not surprisingly, those countries that screen for MTBI and provide follow-up medical evaluations report a greater incidence of screened positive MTBI and medically diagnosed MTBI. Different approaches to the identification of MTBI reflect different assumptions regarding the validity and usefulness of expending resources to identify MTBI. Given the gaps in evidence on these issues, no one country's approach can be judged as more appropriate. As evidence accumulates and experience is gained with different approaches to the identification and treatment of MTBI, approaches to the identification and treatment of military acute and chronic MTBI will likely evolve and may become more similar across countries. In the meantime, since participating countries have developed substantially different approaches to the detection of MTBI, and have provided varied information regarding their experiences with MTBI in conflicts, each country's epidemiology of military MTBI is reported separately. A brief summary of each country's response to a questionnaire regarding epidemiological descriptions of MTBI is presented in this report, with the detailed reports attached in Annex A.

Summary of NATO Working Group Countries Approaches to identify MTBI:

- Post-Deployment Screening: US.
- Evaluation of all service members involved in a "mandatory event" in-theatre: US, Netherlands.
- Use of other in-theatre screening tools:
  - MACE: US, UK, Canada, Netherlands.
  - Pre-deployment Computerized Neuropsychological testing (such as ANAM, ImPACT): US.
  - Post-injury computerized neuropsychological testing (such as ANAM, ImPACT): Provider choice of tools varies in all countries. US – universal pre-deployment testing with ANAM encourages post-injury testing with ANAM, however, other tools can be selected (provider preference).
- ICD-9/10 diagnostic reviews: US, UK, Canada.
- Identification of MTBIs based upon patient presentation with symptoms/complaints: All countries**.**

3.7 CONCLUSIONS

The accumulation of evidence documenting injuries from MTBI with objective neuropsychological testing, combined with evidence from increasingly sensitive neuroradiological studies in sports and military populations has shifted focus towards individuals with MTBI. It is more widely acknowledged now than 10 – 20 years ago that MTBI often result in impairments immediately after injury, and may affect individuals weeks or months after injury. The evidence has been gathered primarily in civilian populations, but there is a growing literature confirming acute symptoms in military populations. Some evidence on blast injuries has been reported, but little data exists yet among service members exposed to pure blast waves. The identification, evaluation, and treatment of individuals with MTBI have thus far occurred unevenly across the NATO Nations surveyed. Each of the NATO Nations participating in the Task Group has acknowledged the potential problems associated with MTBI, and several are examining ways to identify possible MTBI in the future among their service members.

Improved sensitivity of neuroradiological evaluations, such as fMRI, PET, and DTI, has enhanced the ability to study the brains of those with MTBI. The identification and counting of MTBI and the appropriate attribution of chronic problems and symptoms in service members injured while serving combat missions remain subjects of continued investigation. The evidence for acute sequelae following MTBI is compelling, but the question of the role of MTBI as the cause of persisting problems remains controversial. As research continues and the science of objective measurement becomes more developed, controversies over the role of MTBI may resolve.

Chapter 4 – PREVENTION OF MTBI IN MILITARY POPULATIONS

David Tarantino

4.1 INTRODUCTION

Traumatic Brain Injury (TBI) is a leading cause of morbidity in military forces [132]. This is true in military settings, deployed and non-deployed, and results in a significant adverse readiness impact. Risk and causative factors for TBI vary in the garrison and deployed settings, but in both, TBI is often preventable. Application of priority-setting criteria employed by military injury prevention working groups to the challenge of TBI clearly establishes TBI as a high-priority area of focus for prevention efforts [133]. A prevention effort aimed at reducing the incidence and severity of TBI in military populations could dramatically reduce morbidity and improve readiness. Military prevention efforts should utilize proven methodologies while recognizing military-specific considerations [134]. TBI in military populations is a complex prevention challenge, since TBI transcends traditional categorization as an individual patient-provider issue, a public health issue, a component of non-battle injury prevention, a safety issue, and a combat injury issue. As a result, necessary stakeholders in a military TBI prevention program include line leadership, safety personnel, public health professionals, medical providers, and individual service personnel. A military TBI prevention program should emphasize prevention in non-deployed and deployed settings, and consist of leadership, policy, awareness, education/training, dissemination, and surveillance/monitoring components. Utilizing the concept of levels of prevention, by addressing primary, secondary, and tertiary prevention will ensure a comprehensive approach [134].

4.2 LEVELS OF PREVENTION

Leavell and Clark initially developed the concept of levels of prevention as applied to disease processes. These levels – primary, secondary, and tertiary – are also relevant in the setting of TBI, with some modification, reflecting the exposure/injury nature of TBI [134].

4.2.1 Primary Prevention

Primary prevention typically refers to efforts to prevent the initial development of disease and includes health promotion/awareness efforts as well as specific efforts to prevent and avoid disease [134]. Hallmarks of primary prevention are health promotion efforts as well as specific interventions such as seat belt use when operating a motor vehicle [50], [51]. In the case of TBI, primary prevention can be understood to represent efforts to minimize exposures or injuries that could lead to TBI. A comprehensive primary prevention program would include general population-level health promotion efforts to minimize risky behaviours and encourage protective behaviours, as well as interventions targeting high risk groups, to include individual-level provider efforts in the clinical setting.

TBI primary prevention efforts should include strategies to address TBI specifically and as a component of combat injury and of non-battle injury. There is significant experience with non-battle injury prevention in civilian populations as well as military, but less so related to combat injuries [50], [51].

As a leading combat and non-battle injury, TBI uniquely transcends and challenges the line leader, safety, and medical communities. In the combat setting, line leaders have a significant responsibility for the primary prevention of TBI through the provision and utilization of effectively armoured vehicles, the provision and proper use of advanced Personal Protective Equipment (PPE), such as next generation helmets, and the

development and utilization of tactics, techniques, and procedures that balance the risk of exposure to TBI events with operational imperatives. In addition, command enforcement of seat belt usage may help to reduce TBIs. The military safety community has led the way in this regard through the embrace of Operational Risk Management (ORM) methodologies, whereby the sum total of risks and benefits of a particular event or operation are weighed and considered, and risks are systematically mitigated to the greatest extent practical [135]. In this regard, it is essential to include consideration of TBI, along with other injuries, in the potential risks of any operational event. Medical personnel have a role in primary prevention in the combat setting, by reinforcing TBI prevention messaging and keeping line leaders informed of injury trends and surveillance data. In addition, bio-medical research efforts in areas such as the possible neuro-protective effects of nutritional supplements are essential.

Line leaders also have a significant role in primary prevention in the garrison/non-battle injury setting. Safety personnel have traditionally had a significant role in garrison settings, by reinforcing command messages and policies regarding safety and injury prevention, conduct of injury prevention programs, and events such as 'Safety Stand-downs'.

4.2.2 Secondary Prevention

Secondary prevention is traditionally understood as efforts to arrest disease in its earliest or latent stages [134]. The hallmarks of secondary prevention are early detection and early treatment. In the case of TBI, secondary prevention can be understood as efforts to prevent additional concussive exposure or injury, within the window of vulnerability from an initial concussive exposure.

The sports medicine and military medicine communities have increasingly recognized that successive blows to the head or blasts heighten the risk and severity of TBI [34]. It is recognized that an initial exposure to a potentially concussive event, whether or not it results in a diagnosed concussion, can create a sub-clinical window of vulnerability during which a successive exposure could have adverse outcomes.

This post-exposure period, or window of vulnerability, should be and has become an increasing focus of secondary prevention efforts in the sports medicine and military communities. The international military community has addressed this through education and training of line and medical personnel. For example, some countries mandate medical evaluation and a 24-hour rest period after any exposure to a potentially concussive event. Just as 'Return-to-Play' considerations and procedures are increasingly recognized as critical in the sports world, 'Return-to-Duty' considerations, policies, and practices, in the setting of TBI are essential in the military setting. These secondary prevention efforts require the full spectrum approach, already discussed, to include leadership, policy, awareness, education/training, dissemination, and surveillance/monitoring.

The central tenets of a secondary prevention program for TBI would be:

- Heightened awareness of the risks and preventive steps;
- Aggressive case-finding of exposed individuals with early assessment; and
- Collaboration between line and medical to avoid additional blast/injury exposure for personnel during the window of vulnerability.

4.2.3 Tertiary Prevention

Tertiary prevention is traditionally understood as efforts to mitigate the long-term sequelae of a disease [134]. The hallmarks of tertiary prevention are disability limitation and rehabilitation [134]. In the case of TBI, tertiary

prevention can be understood as the provision of care and treatment to TBI patients, with an emphasis on rehabilitation and limitation of disability.

The details of care and treatment programs for TBI patients (as tertiary prevention) are beyond the scope of this chapter and will be addressed elsewhere. In summary, in order to meet tertiary prevention goals, TBI treatment programs should provide comprehensive, interdisciplinary care and treatment to TBI patients in order to promote rehabilitation and minimize disability, with an emphasis on recognition of co-morbid conditions, particularly acute stress reaction and PTSD.

4.3 TBI PREVENTION PROGRAM COMPONENTS

4.3.1 Leadership

The commitment of military leaders throughout the chain of command to a robust TBI prevention program is essential. Leadership of TBI prevention efforts must emanate from senior Commanders through non-commissioned officers and be driven by:

- The recognition that TBI is a leading cause of morbidity in deployed and non-deployed settings;
- A commitment to the health and well-being of subordinate service personnel; and
- A desire to ensure optimal operational readiness of the fighting force.

Senior and unit leaders must be actively involved in the development of policy to promote prevention, in the communication of prevention messages, and the establishment of a culture of accountability regarding TBI prevention. Safety departments and personnel are particularly well-suited to embrace a leadership role in implementation of TBI prevention efforts.

4.3.2 Policy

The development of specific policy directives and guidance is a powerful component of TBI prevention efforts. For example, policies that mandate the wearing of helmets (in combat or in garrison, such as while riding motorcycles on base) can directly address TBI prevention. Military policy toward TBI prevention can range from establishing broad strategy for a comprehensive TBI prevention program, to mandating medical evaluations after blast exposure in combat, to the use of specific clinical practice guidelines in the evaluation and treatment of persons suspected of TBI. A number of NATO Nations and Partners have instituted policies and directives for evaluation of personnel in whom concussion is suspected (reference US, Canada, Netherlands, Australia).

4.3.3 Awareness

A core component of any prevention program is an awareness campaign. Such a health promotion effort can be considered part of primary prevention (detailed below) and is aimed at promoting healthy/safe behaviours and discouraging unhealthy/risky behaviours in order to minimize exposure and risk of injury or disease. Such efforts are commonplace in the military, often developed cooperatively between medical and safety personnel, such as to address sexually transmitted disease, drunk driving, or heat injury. In the case of TBI, awareness efforts would identify and discourage the risks or behaviours that most frequently contribute to TBI.

4.3.4 Education and Training

Education and training are critical elements of any prevention program. In the case of TBI, education and training must target multiple populations, to include line leadership, medical personnel, and individual service members. As a leading combat injury and non-battle injury, TBI warrants similar education/training focus throughout the military career-cycle as other similarly high-profile military-relevant threats such as heat injury or Chemical Biological Nuclear Explosives (CBRNE). This would entail inclusion of TBI education/training in entry-level courses, schools, leadership courses, annual/refresher training, and pre-deployment training. Extensive TBI education/training curricula and materials exist and can be adapted and incorporated by militaries into comprehensive TBI education/training programs.

4.3.5 Dissemination

Communication of TBI prevention strategies, policies, and methods is essential in order to reach and saturate the widest possible audience. Fortunately, militaries typically have extensive capabilities to disseminate essential information. A combination of a clearly-defined chain of command and communication, a 'captive' and disciplined audience, an actively-engaged medical community, and substantial public affairs capacity facilitate prevention messaging in militaries.

4.3.6 Surveillance/Monitoring

Surveillance data drives TBI prevention efforts in multiple ways. First, surveillance data should be used to make the case for, and inform design of TBI prevention efforts [50], [51]. There is significant military surveillance data regarding TBI specifically as well as combat injuries and non-battle injuries in general that can be used to identify and communicate the scope and scale of the problem as well as identify causes and risk factors that are modifiable. Second, surveillance data can be used to monitor the impact of TBI prevention efforts, which is a critical component of measuring and tracking the effectiveness of any prevention program.

4.4 RECOMMENDATION

By any measure, including criteria utilized by military injury prevention working groups, the challenge of TBI in militaries warrants a systematic and focused prevention campaign [133].

Military leaders should develop a military-relevant program of TBI prevention in the garrison and deployed settings by engaging senior line leadership, medical personnel, and individual service members, in an effort to address primary, secondary, and tertiary prevention of TBI, utilizing leadership, policy, awareness, education/ training, dissemination, and surveillance/monitoring strategies. Applying the precepts outlined above will assist militaries in the development of such programs.

Chapter 5 – EDUCATION AND TRAINING

Kit Malia and Sarah Goldman

5.1 INTRODUCTION

MTBI education is a key component in ensuring proper management of service members injured in the military operational environment. Developing, implementing, and evaluating educational delivery is a key component of delivering effective MTBI education and ultimately influencing healthy behaviours that promote prevention and enhance recovery following an injury. There are three primary education and training aspects:

1) Educating the service member and Commanders about the importance of seeking medical attention following a mild traumatic brain injury;
2) Educating medical providers about policies and programs; and
3) Educating the concussed individual and their family members, as part of the medical treatment process.

Evidence indicates that early identification, education, positive expectation of recovery, support and appropriate treatment of MTBI are essential components of improving outcome and preventing persistent symptoms [41], [43]. Psycho-educational interventions that focus on the normalisation of symptoms and positive expectation of rapid recovery are the most effective (Level A scientific evidence) interventions for MTBI. These educational interventions not only reduce the likelihood of persistent symptoms and functional impairments, but also promote medical management to begin at the earliest phase of the care pathway [136]-[139].

The role of line leaders in encouraging the patient to seek care for a MTBI as soon as possible after the injury is considered a crucial aspect in successful management.

Because early intervention is important, MTBI education can assist line leaders' understanding of the importance of seeking prompt care; however, all personnel deployed on military operations can benefit from general MTBI prevention and awareness. Educators and training personnel should emphasize the increased risk of MTBI during military-specific activities (including blast events, vehicle collisions, and combative training). The relevance to line leaders and medical personnel include acute effects of injury, management, the impact on operational performance, and return to duty considerations. Military personnel should be encouraged to report injuries to medical staff, no matter how mild the injury may seem.

Education is an essential component of MTBI management to ensure early identification and proper medical management for those who have sustained MTBI.

5.2 METHODS

In order to better understand the extent of MTBI education, a survey instrument was constructed and disseminated to all NATO HFM-193 members in the spring of 2011. The survey instrument examined the existence, frequency and content of education and training initiatives across 4 domains:

- Pre-Deployment Education/Training Programs;
- Medical Staff Education/Training Programs;

- Non-Medical Staff / Line Managers Education/Training Programs; and
- Education/Training Programs geared towards family members of service members.

The survey instrument also requested specific education and training policy information, efficacy of educational approaches, and relevant research efforts.

The following NATO Nations and Partners responded to the survey: Canada, Germany, Sweden, UK and US. USA surveys were further disseminated to the following branches: Army, Navy, Air Force, and the Marine Corps. France, the Netherlands and Sweden conveyed that they did not have any systematic MTBI educational initiatives. The following survey results are summarized by category and not by individual question.

5.3 RESULTS

5.3.1 Pre-Deployment Education/Training

NATO Nations and Partners described pre-deployment, or just-in-time, training on MTBI in various forms (see Table 5-1). Seven responses specifically answered the pre-deployment section, five of which described existing pre-deployment training programs. These programs shared a number of commonalities:

- A focus on theatre policy;
- Similar target audiences addressing line and medical needs; and
- A general acceptance of the just-in-time approach.

Table 5-1: Summary of Pre-Deployment Training for Military Personnel in NATO Nations and Partners.

Country	Pre-Deployment Training for General Military Personnel
Canada	Canada does not have specific pre-deployment training.
France	France does not have specific pre-deployment training.
Netherlands	The Netherlands does not have specific pre-deployment training. Basic training includes MACE assessment.
Sweden	Sweden does not have specific pre-deployment training.
United Kingdom	UK policy directs MTBI training for medical staff during their initial training and periodically throughout their career. For medics, a specific training module is incorporated into the Role 2/3 hospital validation training package conducted before units deploy to Afghanistan. MTBI training concentrates on educating staff on UK MTBI policy with regards to management on operations, referral criteria for evacuation in-theatre, and return-to-duty requirements.
United States	The US Army has mandatory pre-deployment MTBI training for both medical staff and non-medical staff. Training content varies depending on the target audience. Soldiers and Commanders receive general training while medical providers and medics receive specific training. Topics include the importance of concussion, the impact on soldiers, DoD definition, TBI severity, the mission/vision to identify and treat TBI, line/medical responsibilities following

Country	Pre-Deployment Training for General Military Personnel
United States (cont'd)	a potentially-concussive event, Military Acute Concussion Evaluation (MACE), and theatre resources, etc. The US Navy has mandatory pre-deployment TBI training for medics and providers consisting of 4 hours of didactic teaching and a hands-on MACE segment. The training covers concussion, MTBI policy, MACE, and medical algorithms. The US Air Force provides one-time pre-deployment TBI education and training, which is mandatory. The training is a one-hour class, which covers policy guidance for MTBI in the deployed setting. The US Marine Corps has TBI pre-deployment training courses and a "train the trainer" program. TBI will soon be a mandatory requirement for both medical and line personnel prior to deployment. Line training will last approximately 30 – 60 minutes, and medical training duration is approximately 3 hours.

Training platforms varied in length from 30 minutes, typically targeted to line units, to 2 days for select medical providers. Additionally, the methods of training delivery ranged from service-specific video content, computer-based training, to live presentations. One group reported that their training was still relatively new and that they were in the process of developing training and materials that are more varied.

5.3.2 Medical Training

Eight respondents reported having mandatory MTBI training programs geared towards medical personnel; however, not all organizations had similar training requirements (see Table 5-2). One group reported no available training for a significant number of their medical assets. The duration of the training ranged from 2 days to 40 minutes for medical assets. Six respondents reported training duration in the range from 40 – 90 minutes as the primary training and many reported a multi-part training targeted at skill level (i.e., medics/corpsmen vs. providers). One group did not report having any MTBI-specific content and relied on a traditional mandatory wartime medicine course for neurologists and psychiatrists. This group did not have TBI specific content for non-physician medical staff. Most of the groups described their training delivery as a combination of live presentations, computerized training, and video content. Many of the respondents discussed including training on policies related to the management of MTBI in deployed environments.

Table 5-2: Summary of Medical Training for NATO Nations and Partners.

Country	Medical Training
Canada	Has specific MTBI education and training for medical providers to include medics, nurses, physicians, and social workers (who provide psychological support in-theatre). Training occurs every 6 months (which represents the typical deployment length) in a classroom setting for approximately 45 – 60 minutes. Training consists of a review of theatre medical management guidance.

Country	Medical Training
France	No specific medical education and training is reported.
Netherlands	Training includes 2 hours of MACE training.
Sweden	No specific medical education and training efforts.
United Kingdom	Has mandatory MTBI education and training for medical providers in 2 phases. An initial training and subsequent training are offered periodically (but the exact frequency is not specified in a central policy). There are service-specific variations based on the specialization of staff and the probability of encountering a high degree of concussed patients.
United States	The US Air Force mandates pre-deployment MTBI training for those tasked to deploy (just-in-time training) to include all clinical medics, emergency medical technicians, nurses/nurse practitioners, physician assistants, and physicians. Training lasts approximately one hour and addresses the definition of MTBI, severities of all TBIs, theatre medical algorithms, Military Acute Concussion Evaluation, and an overview of line leader responsibilities. Air Force training was recently added to the Mental Health Readiness Skills Verification (completed every 2 years). The US Navy and the US Army offer similar 1-hour training to all medical providers in the form of a video and didactic dialogue tailored to the specific audience. Recently, the Army, Navy, and Air Force have collaborated to offer a 2-day "TBI for Deploying Providers Course" for deploying providers. This interactive course focusing on MTBI consists of didactic instruction, hands-on activities, and "trauma lanes" to simulate typical scenarios encountered at all levels of theatre care.

5.3.3 Non-Medical Training

Respondents reported highly variable practices related to line officer/service member training (see Table 5-3). Only three of the eight respondents reported mandatory line training. An additional respondent had line training available but not mandated, and three countries did not have any line training available to their military units. One of the three without training reported that line training is currently under development. One respondent reported a baseline or annual training for their line leaders and non-medical military personnel. The remaining three offer just-in-time training to those who are deploying. Training duration for non-medical training ranged from 20 minutes to 90 minutes and content primarily covered policy, reporting requirements, and screening. Only one respondent specifically mentioned targeting high-risk service members within the line community, for example, unique training for Explosive Ordinance Division, Special Forces, and senior leaders.

Table 5-3: Summary of Non-Medical Personnel Training in NATO Nations and Partners.

Country	Non-Medical Training
Canada	No training offered to non-medical/line personnel.
France	No training offered to non-medical/line personnel.

Country	Non-Medical Training
Netherlands	No training offered to non-medical/line personnel.
Sweden	No training offered to non-medical/line personnel.
United Kingdom	Training for non-medics is still under development. Other MTBI 'training' options are under development. Options under consideration include a tri-fold leaflet for issue to all deploying personnel and mandatory training serials in pre-deployment training packages for non-medics.
United States	The US Army has mandated pre-deployment and annual training to non-medical/line personnel in a policy "Warrior Concussion/MTBI Campaign Plan" in June 2011. Training consists of a video and interactive presentation/ discussion and is led by medical personnel. Content consists of causes of MTBI, signs and symptoms, the impact on the warfighter, leadership responsibilities following a potentially concussive event in theatre, and reporting. The US Navy provides training approximately 1 hour in duration as needed to line Commanders, consisting of a video portraying an overview of MTBI. The USMC includes concussion awareness as part of Marine Common Skills training offered at boot-camp and entry-level schools. Additionally, concussion awareness is included in staff courses related to Marine Common Competencies Training.

Line training delivery consists of a combination of live and video content. Additionally, training delivery to theatre personnel, which is unique in many ways, uses less traditional methods such as email and phone training in addition to the video and live training to best educate within the logistical restrictions typical of combat environments.

5.3.4 Family Education and Training

Seven of the eight respondents did not report MTBI education or training for families; the theatre group did mention that they have no family members charged to their care. One respondent was unaware whether they offered training to families.

5.3.5 Additional Education and Training Findings

The survey of the current education and training efforts identified highly variable practice patterns among participating NATO Nations and Partners (see Table 5-4). One respondent reported having internal and external inspections to ensure compliance with training delivery. Another group reported that they operated on the honour system for completion of the required training and had no system in place to check compliance or knowledge assessment. Two groups used pre- and post-test comparison as a means of assessing training effectiveness. One group embedded questions in electronic delivery to assess knowledge.

Table 5-4: Summary of Additional Information Regarding Training in NATO Nations and Partners.

Country	Additional Education and Training Findings
Canada	No additional information to provide.
France	No additional information provided.
Netherlands	Trainings started November 2009. Mandatory screening for all blast exposed soldiers within 25 metres from blast. Issued by Surgeon General.
Sweden	No response provided.
United Kingdom	The assurance of the UK Surgeon General's policies is the responsibility of the Surgeon General's Inspector. External independent assurance may be provided by the UK's Care Quality Commission. Joint Service Policy 950 Leaflet 2-4-3, "The Management of Concussion / Mild Traumatic Brain Injury on Deployed Operations" gives specific guidance to medical personnel and Commanders on the diagnosis and management of UK personnel presenting with concussion/ mild Traumatic Brain Injury (MTBI) in the deployed setting. The management of TBI in general is not particularly singled out (outside specialist clinical groups) for special handling any more than any other medical condition. Since the UK policy was published, there has been an enhanced focus and increased awareness of MTBI.
United States	US training videos incorporate a pre-test and post-test comparison of knowledge and offer continuing medical education credits for completion of MTBI training. Additionally, the US solicits participant feedback of training in an effort to further refine and improve future education and training delivery. The Defense Centers of Excellence for Psychological Health and TBI offer web-based education and training to medical personnel in the form of monthly "webinars." Numerous conferences for continuing medical education are offered throughout the US, including the annual conference sponsored by the Defense and Veterans Brain Injury Center that has over 1,000 attendees from around the world.

In terms of educational policy, five of the eight respondents reported some form of education policy to guide their efforts. Only one respondent reported a research effort into effectiveness of MTBI education. This group conducted a survey of recently deployed units related to the effectiveness of their pre-deployment training. Three other groups reported ongoing program evaluations on their training programs, but they are not conducting any formal research.

Finally, one respondent commented that the NATO survey was a great way to identify gaps in their program. Another respondent commented on how new policies related to MTBI education have resulted in increased awareness on and off the battlefield.

5.4 KEY RECOMMENDATIONS

- Education is an important aspect of the initial and ongoing treatment process.
- Approaches that focus on the normalisation of symptoms and positive expectation of rapid recovery are the most effective.
- Line leaders should receive appropriate education to enable them to understand why it is important to encourage personnel to seek care for a MTBI as soon as possible following an injury.
- Regular education re: MTBI needs to be provided to medical providers.
- Regular education re: MTBI should be considered for non-medical staff.
- Policy guidance re: education and training should be available.

5.5 SUMMARY

5.5.1 USAF

The US Air Force provides pre-deployment specific TBI education and training, which is mandatory. The training is a one-time, one hour class, which covers policy guidance for MTBI/concussion in the deployed setting.

For medical providers (EMTs, nurses, nurse practitioners, physician assistants, physicians) the course covers TBI definition, severity, clinical practice algorithms, MACE, and an overview of line leader responsibilities. The TBI course was recently added to the Mental Health Readiness Skills Verification (completed every two years).

For non-medical personnel (non-standard forces E5 and above, EOD community E6 and above, group and squadron Commanders) the course covers overview of TBI and line leader responsibilities per policy guidance, including details on reporting mechanism.

5.5.2 USN

The US Navy (USN) has mandatory pre-deployment TBI training for medics (medical officers, corpsmen, first responders) consisting of 4 hours, didactic plus hands-on observation of the Military Acute Concussion Evaluation (MACE) that covers concussion, the TBI Department of Defense Instruction (DoDI), MACE, and Clinical Practice Guidelines (CPGs. There is also a one-hour annual training session for all providers, which includes a one hour video for non-medics that provides an overview of concussion/TBI, provided as needed.

5.5.3 USMC

The US Marine Corps (USMC) has TBI training courses, which will soon be mandatory for deploying medical and line personnel. The version for medical personnel (medics, nurses, physicians and social workers who provide psychological supports services in-theatre) is three hours long and covers MACE/DTM/CPGs/theatre-

specific policies, practices, MOI, basics, definitions, etiology, prevalence, military relevance, field diagnosis, reporting, prevention, treatment, referral, and tracking. Clinical in-theatre guidelines are reviewed and explained. The non-medic version is one-hour long and covers leadership responsibilities with regard to TBI. Medic training is renewed semi-annually.

5.5.4 United States

The US Army (USA) had mandatory pre-deployment TBI training for both medics and non-medics. It is a 90-minute course. Soldiers and Commanders receive more general training. Medical providers and medics receive more specific training, which is required annually. Topics may include the importance of concussion, impact on the warfighter, DoD definition, TBI severity, mission/vision to identify and treat TBI, line/medical responsibilities regarding the DTM 09-033, Military Acute Concussion Evaluation, and theatre resources.

5.5.5 Canada

Canada does not have specific pre-deployment TBI training. It does have mandatory semi-annual TBI training for medics, however. The training is an hour-long class given to medics, nurses, physicians and social workers (latter provide psychological supports services in theatre), in which clinical in-theatre guidelines are reviewed and explained.

5.5.6 United Kingdom

Recently issued UK policy directs MTBI/concussion training for medical staff to be conducted during initial training, as part of through-life continuation training and prior to deployment on operations. The exact delivery model for this training varies between the three single Services (Army, Navy and Air Force). These delivery models are being developed at present. In addition to training for medical staff, the intention is to raise awareness for all other personnel (including the Command Chain) through a Defence Internal Notice (DIN) and as part of the medical briefing process on arrival in a deployed theatre (RSOI training). Training on the wider subject of TBI is bespoke to medical specializations dealing with these injuries and dictated by national standards and Royal College syllabi.

TBI treatment is governed by Joint Service Policy 950 Leaflet 2-4-3 ‘THE MANAGEMENT OF CONCUSSION / MILD TRAUMATIC BRAIN INJURY ON DEPLOYED OPERATIONS’. This policy gives guidance to medical personnel and Commanders on the diagnosis and management of UK personnel presenting with concussion/mild Traumatic Brain Injury (MTBI) in the deployed setting. The management of TBI in general is not particularly singled out (outside specialist clinical groups) for special handling any more than any other medical condition. There is an enhanced focus on concussion/MTBI as a result of the recent launch of UK policy on the subject.

For medics, a specific training module is incorporated into the Role 2/3 hospital validation training package conducted before units deploy to Afghanistan. MTBI training concentrates on educating staff on UK MTBI policy, with regard to management on operations, referral criteria for evacuation in theatre and R2 requirements.

Training for non-medics is still under development. Other MTBI ‘training’ options are under development. Options under consideration include a tri-fold leaflet for issue to all deploying personnel and mandatory training serials in pre-deployment training package for non-medics.

5.5.7 Netherlands

As of November 2009, the Netherlands Armed Forces had mandatory pre-deployment TBI training for both medics and para-medics. It is a 90-minute course. Soldiers and Commanders received no specific training. Medical providers and medics received specific training on assessment of MACE. Topics included the importance of concussion, TBI severity, and policies for return to duty. An interdisciplinary research program was initiated between neurology, rehabilitation medicine and psychiatry, with follow-up of those who were MACE screened until one year post deployment.

Chapter 6 – MANAGEMENT AND SYSTEM OF CARE OF MTBI

Kathy Helmick, Kit Malia, David Tarantino, Bryan Garber and Eric Vermetten

6.1 INTRODUCTION

The aim of the various policies regarding Traumatic Brain Injury (TBI) is to detect concussion / Mild Traumatic Brain Injury (MTBI) as early as possible, in order to provide early treatment. Although most service personnel will recover spontaneously within the first few weeks post injury, a minority may require ongoing treatment. For both of these groups of personnel it is essential to provide appropriate targeted treatment once identification has taken place. For the former group, this treatment will help to prevent the development of psychological reactions to the injury symptoms and will thereby improve speed of recovery, and for the latter group, treatment will help them learn how best to manage any remaining symptoms and how to deal with their developed psychological reactions to the symptoms.

There are documented effective treatments for those who sustain severe and penetrating brain injuries, but there are fewer empirically validated and effective interventions for concussion/MTBI. The current effective treatments for concussion/MTBI supported by scientific evidence include rest and education, including the positive expectation of recovery. The treatments provided to personnel who do not recover within the first few months draw from the scientific evidence base for various psychological therapies, but these have not been studied specifically in the context of concussion/MTBI.

Treatment can vary depending on the Role/Echelon. (A description of NATO's Role/Echelon care delivery is provided in Annex B). Early identification, support and treatment of concussion/MTBI are important. Current evidence points to success from early educational intervention, which should be focused on an expectation of rapid recovery [41], [43]. This will reduce the likelihood of persistent symptoms developing in the majority of cases and allow management to take place predominantly in the Role 1 / primary care setting.

Persisting symptoms may or may not be associated with a reported concussion/MTBI, but where it becomes apparent that the condition is not resolving in the expected timeframe, early onward referral to the next Role/Echelon should take place.

For many NATO Nations, service personnel may appear in the health system of care for complaints that may be related to MTBI (post-concussion symptoms), but there is no systematic process of MTBI care. At the time of this report, Canada, the UK and the US, have promulgated Clinical Practice Guidelines (CPGs) for the treatment/management of MTBI in the deployed setting. What follows is a description of the common elements of these three approaches, followed by a detailed description of the guidelines by country. In 2009, the Netherlands instituted a study protocol to evaluate personnel within 25 meters of a blast. While not a clinical practice guideline, this is described separately later in this chapter. Where appropriate, this topic has been broken down into a presentation of what takes place at each Role/Echelon by Nation.

6.2 COMMON ELEMENTS OF CURRENT CLINICAL PRACTICE GUIDELINES

6.2.1 Concussion MTBI Definition

All three CPG's provide a definition of concussion/MTBI which are largely similar (see Table 6-1).

Table 6-1: Definition of MTBI in UK, US and Canadian Guidelines.

UK	US	Canada
LOC-for 30 min or less; and/or AOC from a moment (e.g. confused, dazed) up to 24 hours; and/or PTA-less than 24 hrs; and/or Transient neurological abnormality +GCS no lower than 13 (after 30 min)	LOC 0 – 30 min and/or AOC from a moment up to 24 hours; and/or PTA from 0 to 1 day. Normal structural imaging.	Concussion may be diagnosed if the following criteria or met: a) **Head injury event** (blast, fall motor vehicle accident, head impact). b) **Alteration of consciousness** (dazed, confused, PTA or LOC).

6.2.2 Treatment Initiation

Both the UK and Canada employ a symptom-based approach for medical evaluation, whereby individuals who have concerns about MTBI self-report, or line Commanders refer individuals for evaluation. Since 2010, the US has implemented an event-based approach, in which all military personnel who are within 50 meters of a blast event or other potentially concussive events are required to undergo medical evaluation.

6.2.3 Evaluation for Acute Neurosurgical Conditions

All three algorithms incorporate a series of "Red Flag" symptoms and signs which may be indicative of an acute neurosurgical condition and warrant evaluation with neuroimaging and specialist consultation.

6.2.4 Neurocognitive Evaluation

Both the US and Canada utilize the Military Acute Concussion Evaluation (MACE) tool to evaluate both symptoms and neurocognitive performance as part of their in-theatre algorithms. The UK utilizes a concussion/MTBI Score Chart to monitor progression/resolution of symptoms and signs. The US will routinely perform more detailed neurocognitive testing in theatre, while both Canada and the UK leave this to the discretion of the clinician.

6.2.5 Exertional Testing

Exertional testing may be performed on individuals who are asymptomatic and show normal neurocognitive performance in a stress test. Exertional testing is done before making return to duty determinations. This is part of the US and Canadian algorithms, but not included by the UK.

6.2.6 Mandatory Minimum Rest Period

All three guidelines require a mandatory minimum 24-hour rest period in all suspected cases of concussion, as the operational situation allows.

6.2.7 Explicit Return to Duty Criteria

The UK requires the individual to show resolution of symptoms and signs based on concussion/MTBI Score Chart. The US and Canada require that the individual be asymptomatic with a MACE Score > 25, following exertional testing.

6.2.8 History of Multiple Concussions

In the US guidelines, 3 concussions in the past 12 months warrants a comprehensive in-theatre evaluation that includes a neurological examination, a functional evaluation, a neuroimaging study and a thorough neuropsychological assessment (see Clinical Management Algorithm #4). The Canadian guideline recommends specialist evaluation, and there is no specific guidance regarding this in the UK algorithm.

6.2.9 Repatriation from Theatre

In the Canadian guideline, individuals who are symptomatic for more than 7 days are evacuated to Role 3 for specialist assessment. These individuals are likely to be evacuated from theatre. In the US guideline, individuals who remain symptomatic after primary care evaluation and treatment are transferred to an in-theatre Concussion Care Center for more advanced and further treatment. In the UK guideline, individuals who remain symptomatic during ongoing monitoring over a period of 14 days should be considered for evacuation to Role 2/3 and possibly removed from theatre.

6.2.10 Role 4 Management

There is considerable variation between the US, the UK and Canada in where care is delivered. In the UK, care is centralized at a specialty facility. In the US, care is delivered at the primary care level and then at more specialized centres for more complicated cases. In Canada, most of the care is delivered by primary care physicians, with specialist consultation as required. Guidelines are in place for the US, the UK and Canada, and are summarized below. In all 3 cases, emphasis is on a symptom-based approach to management.

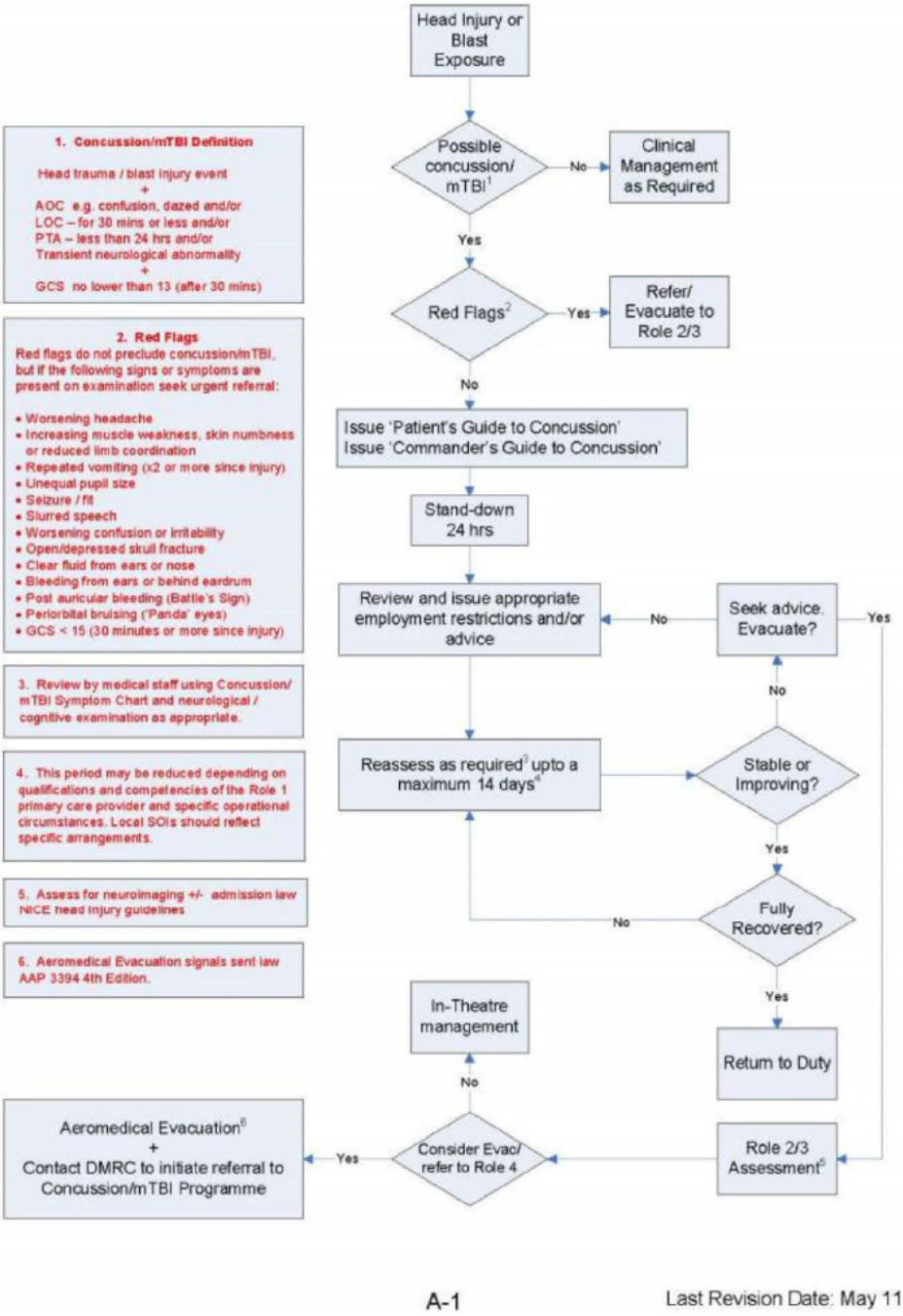
6.3 DETAILED DESCRIPTION OF EXISTING GUIDELINES IN NATO NATIONS AND PARTNERS

6.3.1 United Kingdom

An overview of the UK system is provided in Annex C. The algorithm in Figure 6-1 guides medical staff in the management of concussion/MTBI in the deployed setting both for the Role 1 primary care provider and at Role 2/3.

JSP 950 Leaflet 2-4-3

ANNEX A – CONCUSSION / MTBI CLINICAL MANAGEMENT ALGORITHM



A-1 Last Revision Date: May 11

Figure 6-1: UK Concussion/MTBI Clinical Management Algorithm.

The UK guidelines aim to reduce the impact of concussion/MTBI on the patient by ensuring early education and information through use of a patient information leaflet (Figure 6-2) and timely symptom-based intervention, whilst at the same time minimizing the operational impact of unnecessary evacuation.

JSP 950 Leaflet 2-4-3

ANNEX B – PATIENT'S GUIDE TO CONCUSSION

What happened to me? Your assessment indicates that you have had a concussion. This is also sometimes referred to as a "mild traumatic brain injury" (mTBI).

What is a concussion? A concussion is a head injury from a hit, blow, or jolt to the head (either from a direct blow or from being close to a blast) that briefly knocks you out (loss of consciousness), or makes you feel confused or "see stars" (alteration or change in consciousness).

What are the symptoms? Immediately or soon after the concussion, you may feel disorientated and may experience headaches, dizziness, balance difficulties, ringing in the ears, blurred vision, nausea, vomiting, irritability, temporary gaps in your memory, sleep problems, or attention and concentration problems.

How long does it last? Most people recover completely from concussion. Symptoms usually begin to improve within hours and typically resolve completely within days to weeks.

Recovery. Recovery is different for each person and depends on the nature of the injury. The most important thing you can do is to allow time for your brain to recover and this is best done by a combination of rest and a graduated return to full duties.

Why does a concussion affect return to duty? Concussion can reduce your effectiveness which could impair your performance and endanger you or your colleagues. If you get another concussion before healing from the first one, you are at greater risk of a more serious injury.

What happens now that I have been diagnosed with a concussion?

- You may have been given a period of stand down or light duties. You will be advised when you need any medical review. Be honest about your symptoms when you see your medical provider - they are protecting you and your unit.
- Your military line manager will be informed of any work restrictions. With your consent they will receive a separate leaflet providing guidance on concussion and advice on how to promote your quick recovery.
- Rest - Avoid exerting yourself physically (heavy lifting, exercising, etc). Avoid mental exertion (e.g. writing reports and activities requiring you to concentrate hard).
- Return to Duty - Expect to recover fully and RTD. Your medical provider will continue to evaluate you and will determine (in conjunction with you and your military Line Manager) when it's safe for you to RTD.

Do's & Don'ts

Things That Speed Recovery	Things That Slow Recovery
• Maximise downtime/rest during the day • Get plenty of sleep • Protect yourself from another concussion: avoid contact sports • Let others know that you've had a concussion so they can watch out for you • Return immediately to your medical staff if you're feeling worse or experience any warning signs*	• Another concussion before healing of the first one • Alcohol • Inadequate sleep (made worse by caffeine or 'energy-enhancing' products) • Aspirin, ibuprofen, and other over-the-counter pain medications unless instructed by your doctor • Sleeping aids and sedatives unless instructed by your doctor

B-1 Last Revision Date: May 11

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Coping measures. The following table lists some practical coping measures that you are advised to use:

Symptom	Action
Slower Thinking, Confusion and Difficulty Concentrating	•Establish a daily routine and structure your time. •Ask others to slow down and to repeat things if needed. •Allow extra time to complete tasks. •Break activities down into smaller periods and take more rests. •Do only one thing at a time. •Avoid distractions e.g. turn off the TV/radio when working. •Consult with friends/colleagues when making important decisions.
Memory problems	•Put important items in the same place all the time. •Use a pen and notebook to keep track of things that need to be done or are hard to remember. Keep to hand at all times. •Ask friends and colleagues to remind you.
Irritability	•Walk away from situations if they cause annoyance. •Actively use relaxation techniques. • Working out in the gym can help if it does not over-tire. •More rest can reduce irritability.
Fatigue	Rest whenever possible.
Anxiety, sleep problems, and low mood	These tend to be reactions to the other problems and tend to improve as other symptoms reduce. If you are worried about them see your medical staff.

* **Warning Signs.** If you begin to experience any of the following, seek immediate medical attention:

• Worsening headache • Worsening balance • Double or disturbed vision	• Decreasing level of alertness • Increased disorientation • Repeated vomiting	• Seizures or fits • Unusual behaviour • Amnesia/memory problems

Figure 6-2: UK Patient's Guide to Concussion.

The role of the patient's line manager is considered crucial in the management of concussion/MTBI during the early post-injury phase, and advice for Commanders is therefore included in Figure 6-3. 'Red Flag' indicators are highlighted to assist medical staff in identifying when early onward referral is appropriate or when further advice should be sought.

JSP 950 Leaflet 2-4-3

ANNEX C – COMMANDER'S GUIDE TO CONCUSSION

Why have I received this? Medical staff have determined that one of your personnel has sustained a concussion - sometimes also referred to as a "mild traumatic brain injury" (mTBI). The patient has consented to sharing this information with you. As the patient's military line manager you have an important role in promoting their recovery.

What is a concussion? A concussion is a head injury from a hit, blow, or jolt to the head (either from a direct blow or from being close to a blast) that briefly knocks the person out (loss of consciousness), or makes them feel confused or "see stars" (alteration or change in consciousness).

What are the symptoms? Immediately or soon after the concussion, the affected individual may feel disorientated and may experience headaches, dizziness, balance difficulties, ringing in the ears, blurred vision, nausea, vomiting, irritability, temporary gaps in memory, sleep problems, or attention and concentration problems.

How long does it last? Most people recover completely from a concussion. Individuals should be reassured that symptoms usually begin to improve within hours and typically resolve completely within days to weeks.

Recovery. Recovery is different for each person and depends on the nature of the injury. The most important thing is to allow time for the brain to recover and this is best done by a combination of rest and a graduated return to full duties.

Why does a concussion affect return to duty? Concussion can reduce effectiveness which could impair an individual's performance. In the operational environment this may endanger them or their colleagues. If the individual sustains another concussion before healing from the first one, they are at greater risk of a more serious injury.

How can I help? Medical staff will already have reassured the patient and encouraged them to expect a full recovery - you should reinforce this message. Evidence shows that you can assist the speed of recovery by reducing the demands placed upon the individual to a level that does not worsen their symptoms. Medical staff will advise on any 'stand down' or period of light duties/restricted activity but you are better placed to tailor this to the individual's role. Match duties to the individual's ability and level of symptoms. Encourage them to talk regularly with you about this. If symptoms get worse this may indicate they are pushing themselves too hard. Routine and familiar tasks will be easier than new and unfamiliar ones. Encourage personnel to take extra breaks if needed. Once symptoms have stabilised increase the amount of work gradually.

Do's & Don'ts. Patients are advised to do the following:

Things That Aid Recovery	Things That Impair Recovery
• Maximise downtime/rest during the day • Get plenty of sleep • Protect from further concussion; no contact sports • Let colleagues know that they've had a concussion so they can look out for them – use 'buddy' system • Return immediately to medical staff if they are feeling worse or experience any warning signs*	• A further concussion before healing of the first one • Alcohol • Inadequate sleep (made worse by caffeine or 'energy-enhancing' products) • Aspirin, ibuprofen, and other over-the-counter pain medications unless instructed by medical staff • Sleeping medication unless instructed by MO

Coping Measures. The following table lists some practical coping measures that patients are advised to use:

Symptom	Action
Slower Thinking, Confusion and Difficulty Concentrating	•Establish a daily routine and structure their time. •Ask others to slow down and to repeat things if needed. •Allow extra time to complete tasks. •Break activities down into smaller periods and take more rests. •Do only one thing at a time. •Avoid distractions e.g. turn off the TV/radio when working. •Consult with friends/colleagues when making important decisions.
Memory problems	•Put important items in the same place all the time. •Use a pen and notebook to keep track of things that need to be done or are hard to remember. Keep to hand at all times. •Ask friends and colleagues to remind them.
Irritability	•Walk away from situations if they cause annoyance. •Actively use relaxation techniques. • Working out in the gym can help if it does not over-tire. •More rest can reduce irritability.
Fatigue	Rest whenever possible.
Anxiety, sleep problems, and low mood	These tend to be reactions to the other problems and tend to improve as other symptoms reduce. If affected personnel are worried about them see medical staff.

C-1 Last Revision Date: May 11

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Figure 6-3: UK Commander's Guide to Concussion.

Defence Medical Rehabilitation (DMRC) Headley Court is the DMS centre of expertise on the treatment of symptoms associated with concussion/MTBI. Where diagnostic confusion exists, advice may also be sought from the DCMH teams (for mental health symptoms), or from a military neurologist.

6.3.1.1 Pre-Role 1: The First Responder

The UK's current symptom-based approach does not require mandatory medical assessment (screening) following exposure to head injury / blast incident. However, medical staff should adopt a proactive approach following any high risk incident and be alert to the possibility of concussion/MTBI in those involved.

6.3.1.2 Role 1

Personnel who are medically stable can be held at Role 1 for a maximum of 14 days, after which referral or advice must be sought from Role 2/3. The policy does not differentiate between those Role 1 locations with a Medical Officer (MO) or Nursing Officer (NO) and those remote locations where other Role 1 medical personnel (RN Medical Assistants (MA), Combat Medical Technicians (CMT and RCMT) and RAF Medics) may be operating without immediate supervision.

These guidelines are deliberately generic, and detailed Standing Operating Instructions (SOIs) may need to be developed for specific operating environments, taking into account the experience and qualifications of medical staff at Role 1 locations. In such cases, it may be appropriate for local SOIs to reduce the period for which concussion/MTBI patients may be held under review before referral to a MO/NO.

The principle of treatment is to foster natural recovery by reassurance, education and monitoring. Periodic medical review will be required, tailored to each individual, until symptom free and returned to duty.

The majority of patients will present to Role 1 medical staff soon after a head injury/blast incident. Assuming no other injuries take precedence, medical staff should take a careful history to determine the details of the suspected concussion/MTBI event. Any physical, cognitive and emotional symptoms should be determined and a basic neurological examination[1] conducted to exclude any 'red flags' that may require evacuation or referral. It should be noted that 'red flags' do not necessarily preclude a diagnosis of concussion/MTBI but merely provide an indicator to seek further medical opinion.

Where a diagnosis of concussion/MTBI is made, the following action is to be taken:

- Reassure and advise patient. Issue 'Patient's Guide to Concussion' (Figure 6-2).
- Issue 'Commander's Guide to Concussion' (Figure 6-3) for patient's military line manager with appropriate verbal consent recorded in the medical record. Where consent to release information is not given, this must also be recorded.
- Stand-down patient for 24 hours and consider subsequent employment restrictions (see below).
- Review patient at 24 hours; as required thereafter; and prior to return to duty.

Figure 6-4 provides the document that should be used by medical staff to chart progress of concussion/MTBI symptoms. The ability to demonstrate an improving trend in symptoms will be reassuring to the patient and may assist the recovery process. Conversely, a deteriorating trend in symptoms may highlight to medical staff

[1] As a minimum this should include standard head injury observations as per F Med 290 'Head Injury Observation Chart', i.e., GCS score, pupil reaction and symmetry, limb power, pulse and blood pressure.

the need for onward referral. Once completed, the record will become part of the patient's medical record and should be managed accordingly.

JSP 950 PROTECT – MEDICAL (when completed) LEAFLET 2-4-3

ANNEX D - CONCUSSION/mTBI SYMPTOM SCORE CHART FOR USE BY MEDICAL STAFF

Patient's Name:

Service No:

Unit:

Ask the patient to score signs and symptoms using the following scale:

0 = Not experienced 1 = Not a problem 2 = Mild 3 = Moderate 4 = Severe

	Date & Time							
Signs & Symptoms								
Physical								
Feeling Dazed								
Headache								
Dizziness or Balance problems								
Nausea and/or vomiting								
Feeling fatigued								
Sleep difficulties								
Blurred or Double vision								
Sensitivity to bright light or loud noise								
Hearing difficulty								
Numbness or tingling								
Cognitive								
Confusion								
Disorientation								
Difficulty remembering things								
Slowed thinking skills								
Difficulty concentrating								
Problems with multi-tasking								
Behavioural & Emotional								
Anxiety								
Feeling agitated								
Being irritable, easily angered								
Feeling depressed or tearful								
Mood swings								
*Store in medical record when complete	**Signature**							

D-1 Last Revision Date: May 11

Figure 6-4: UK Concussion/MTBI Symptom Score Chart for Use by Medical Staff.

There is no specific drug treatment for the management of concussion/MTBI, but simple analgesics (e.g., paracetamol) may be used for headache symptoms.

All patients diagnosed with concussion/MTBI are to be given a minimum 24-hour rest period whenever the operational situation allows. Assuming the individual can be adequately rested and attend for any necessary medical reviews, this stand-down should take place in the individual's normal place of duty.

Following this period of stand-down, appropriate employment restrictions should be tailored to individual circumstances and managed in collaboration with the patient's local chain of command. This will be important in protecting the patient from stressors which may delay recovery, and should include steps to minimize the risk of exposure to any further concussion/event before full recovery has taken place.

If all symptoms resolve within 24 hours of the injury, the individual may return to full duties following local medical review but should be advised to seek further medical assistance if symptoms return. Those individuals not fully recovered after this period should be reviewed and considered for further stand-down or a limited return to work. This graduated return to full duties must be tailored to their rate of recovery as measured by the presence or absence of concussion/MTBI symptoms, and based on a local risk assessment.

Examples of common restrictions that should be considered after a concussion/MTBI event are below:

- Unfit weapon handling and/or guard duties.
- Unfit to operate unguarded machinery.
- Unfit to operate vehicles (e.g., MT, aircraft, marine craft, as required).
- Unfit extended working hours / shift work; or fit limited working hours only.
- Unfit strenuous physical exertion including physical training.

Individuals who have not recovered adequately by 14 days post-incident are to be referred to Role 2/3 for further assessment.

Particular care should be taken where there is a history of previously diagnosed concussion/MTBI incidents. Any stand-down period may need to be extended and medical staff should seek advice and/or consider early referral to a higher level of care where there is a history of multiple concussion/MTBI incidents.

6.3.1.3 Role 2 or 3

Suspected concussion/MTBI cases referred to Role 2 or 3 will undergo more detailed neurological and cognitive examinations that may include neuroimaging and specialist advice, in accordance with national best practice in secondary care:

a) JDP 4-03.1 Clinical Guidelines for Operations (CGOs) – Section 3, Treatment Guideline 9a, 'Head Injury'; and

b) NICE Clinical Guideline 56–Head Injury dated 28 Nov 1997 (www.nice.org.uk/CG56).

Where the diagnosis remains unchanged, subsequent management will be determined by the local situation and any theatre medical holding policy in force. It may be appropriate to return the patient to their forward location to continue under Role 1 management or to retain the patient in a rear echelon area.

Where evacuation from theatre is recommended for a primary diagnosis of concussion/MTBI, the referring clinician is to ensure that appropriate arrangements are made for review of the patient in the Defence Medical Rehabilitation Centre (DMRC) Headley Court and that any aeromedical evacuation signals are addressed accordingly.

6.3.1.4 Role 4

Provision of concussion/MTBI care in the UK Home Base is focused on DMRC Headley Court where a multi-disciplinary team delivers the 'Concussion/MTBI Programme'. The detailed management of each patient referred to DMRC is tailored to the individual case, but in summary, Role 4 management is based on a three-tiered approach (see Annex C for a fuller description):

- **Tier 1** – Assessment by interview followed by specific therapeutic goal-driven phone and web-based therapy for those who have persistent symptoms.
- **Tier 2** – Enrolment in a two-week intensive in-patient treatment group.
- **Tier 3** – Tailored follow-up programme to ensure symptoms remain managed following return to full-time work.

In addition to referrals from operational theatres, DMRC assesses all in-patients and out-patients who may be at risk of concussion/MTBI. Similar routine assessment also takes place on all casualties evacuated to RCDM Birmingham from any operational theatre.

Recognising that in some cases patients may not report their MTBI/concussion symptoms until after leaving an operational theatre, the MTBI team at DMRC will also accept medical referrals from elsewhere within the DMS in the normal manner.

6.3.2 United States

As MTBI has emerged as a leading combat injury, the management of concussion in the deployed setting has been codified in a Defense Department level policy (Department of Defense Instruction 6490.11), signed 18 September 2012, that directs both the reporting requirements as well as clinical care (Annex D). There are 4 potentially concussive events that trigger a mandatory medical evaluation for concussion. These events are:

- Involvement in a vehicle blast event, collision or rollover;
- Presence within 50 meters of a blast (inside or outside);
- A direct blow to the head or witnessed loss of consciousness; and
- Exposure to more than one blast event (the service member's Commander shall direct a medical evaluation).

The clinical care rendered is organize by Roles and is outlined in the following sections. The complete clinical management algorithms, revised in July 2012, are attached as Annex E.

6.3.2.1 Pre-Role 1: First Responder

First Responder care (pre-Role 1) is a central component of modern battlefield trauma care. First responder care includes self-care, buddy care, and medical first responder (medic/corpsman) care.

It is essential that first responder care adapt to the challenge of MTBI on the battlefield through appropriate tactics, techniques, and procedures, as well as education and training. It is increasingly recognized that repeat exposures to concussive events, without adequate treatment and resolution of symptoms, can have significant adverse consequences [98].

The central imperatives for first responder MTBI care are to triage for severity of injury by identifying red flags that may necessitate a neurosurgical intervention, to recognize a potentially concussive event exposure, to remove from combat to avoid potential repeat exposure, as well as to not degrade operational effectiveness of themselves and possible injury, and to evacuation to appropriate level of care.

It is essential to maintain an index of suspicion for concussion/MTBI in a trauma setting, where more obvious injuries (amputation, etc.) might distract attention from an 'invisible' concussion/MTBI.

Standard trauma assessments (primary and secondary surveys) must include assessment of neurological function to identify potential presence and severity of MTBI/concussion. If a concussion/MTBI is suspected, then proper triage is essential to determine transport and treatment decisions. A useful tool for MTBI triage is the presence/ absence of red flags – such as witnessed loss of consciousness, persistent altered mental status, or abnormal neurological examination. The presence of one or more red flags should prompt immediate medical evacuation to an appropriate/higher level of care.

Service personnel exposed to potentially concussive events should be removed from combat for further evaluation. The purpose of removing the service member from combat is three-fold:

1) Prevent potential repeat exposure;
2) Ensure proper evaluation and subsequent treatment for concussion, if warranted; and
3) Maintain operational readiness of the force by removing a patient who may be impaired to function optimally.

All patients with potentially concussive event exposures should be referred to a medical provider (Role 1 or higher) for thorough evaluation, treatment, and disposition.

The above principles and practices necessitate specific skills and actions by the various categories of first responders in the setting of MTBI on the battlefield. Individual personnel are responsible for self-care, so in the setting of potential MTBI, they must be prepared to identify and report any potentially concussive event exposure to a buddy, medical first responder, or medical provider. Personnel are also responsible for providing buddy care on the battlefield, so in the setting of potential MTBI, they must be prepared to identify and report any potentially concussive event exposure, remove the victim from combat, and conduct basic triage. Medical first responders have the most critical role in identification and triage of battlefield MTBI, and must be prepared to recognize potentially concussive exposures, remove the patient from combat, conduct detailed trauma assessment – to include MTBI triage using 'red flags', make a determination regarding medical evacuation and appropriate level of care, and refer the patient for evaluation, treatment, and disposition by a medical provider. Of note, in remote/dispersed operations, immediate transport to a Role 1 facility/medical provider may not be feasible. This may require initiation of concussion evaluation and treatment by the medical first responder (discussed in more detail below).

It is essential that militaries include the above principles and practices in first responder Tactics, Techniques and Procedures (TTPs) and education/training – such as Combat Lifesaver Course and Tactical Combat Casualty Course (CLS/TCCC).

6.3.2.2 Role 1

An example of a Role 1 capability is a Battalion Aid Station. Role 1 capabilities have a central role in the management of MTBI/concussion in the deployed setting.

As described above, first responders should conduct initial triage of suspected MTBI and evacuate cases with identified red flags to higher levels of care (Role 2 or 3). Patients with potentially concussive event exposures (and no red flags) should be sent to the nearest Role 1 facility for thorough evaluation, treatment, and disposition or referral. Of note, in settings of dispersed/remote operations, even Role 1 facilities may not be proximate enough for immediate transport. In these cases, up to 24 hours, medical first responders (medics/corpsmen) may initiate some of the evaluation and treatment measures described below, preferably with at least verbal coordination with a medical provider.

Evaluation, treatment and disposition of concussion in the deployed setting should be standardized to the greatest extent possible through the use of evidence-based clinical practice guidelines. Evaluation of potential concussion requires a detailed history and physical examination – with particular emphasis on exposure history, loss or alteration of consciousness, amnesia; symptoms of concussion; and neurological examination. A test of cognitive function is another important evaluation tool. The US military uses the MACE, which includes history, symptoms, neurological examination, and cognitive function components (MACE July 2012, version 4.0 – Annex F).

Treatment of concussion should focus on expectancy of recovery, patient education, rest, and management of symptoms [138]. The US military has developed clinical practice guidelines for the management of concussion in the deployed setting which emphasize these approaches (US Clinical management algorithms – Annex E). Role 1 facilities are well-suited to provide these initial, basic interventions, for uncomplicated concussions, with the added benefit of proximity to units. Disposition, or return-to-duty decisions, in the setting of concussion, requires a standardized approach (see Chapter 2, Section 2.4). Minimal considerations for return-to-duty decision include resolution of symptoms, normalization of neurological examination, as well as some form of exertional testing. Management of concussion with basic interventions such as education, rest, and symptom management is generally appropriate at Role 1 facilities for the initial 3 – 7 days. If operational realities make such management impossible, or the patient worsens or fails to improve within 3 – 7 days, then consideration must be given to referral to a higher level of care (Role 2 or 3).

6.3.2.3 Role 2/3

Typically a Role 2/3 facility, whether surgically equipped or not, would not have significant increased capability over a Role 1 facility (other than increased holding capacity) to manage concussion in the deployed setting. However, in light of experiences with concussion care centres (augmented Role 2/3 facilities) in Afghanistan has demonstrated efficacy for management of concussion in the deployed setting.

The function of Role 2/concussion care centres in deployed settings should be to provide comprehensive concussion care for uncomplicated or refractory concussions.

Role 2/3 concussion care centres could receive patients via ‘step-down’ from a Role 3 after ruling out moderate or severe TBI and addressing other trauma, via direct referral/transport, or via referral from Role 1 facilities.

Desired capabilities at Role 2/concussion care centres include medical evaluation/treatment, physical therapy, occupational therapy, behavioural health evaluation/treatment for co-morbidities, complementary/alternative therapy (acupuncture), and neurocognitive testing. Of note, this level of capability – which does not require

specialist care or advanced imaging found at Role 3 facilities − has been demonstrated to be effective in the management of the vast majority of concussions.

Certainly, the above capabilities could be positioned or co-located at a Role 3 facility, but placement at a Role 2 facility has the advantage of unit proximity.

Evaluation, treatment, and disposition principles described for Role 1 facilities remain the same at Role 2 facilities; however, with enhanced capability to conduct more thorough and comprehensive evaluation, treatment, and disposition, ideally through enhanced clinical practice guidelines. A board-certified primary care physician, such as a Family Medicine/Sports Medicine physician (versus the General Medical Officer often found at Role 1 facilities) can provide enhanced medical evaluation and management of concussion. Physical and occupational therapists can provide enhanced rehabilitation modalities. A behavioural health provider can address potential co-morbid conditions, such as acute stress reactions, which can complicate recovery from concussion. Alternate therapies such as acupuncture have shown promise in managing the symptoms of concussion in the deployed settings. Neurocognitive testing, such as the Automated Neuropsychological Assessment Metric (ANAM), can be used to evaluate treatment progress and enhance informed return-to-duty determinations.

Patients who demonstrate worsening or refractory symptoms beyond 14 – 21 days, or those with multiple concussions, should be considered for referral to a Role 3 facility with specialist (neurologist) capability and advanced neuroimaging.

6.3.2.4 Roles 4 and 5

Treatment for concussion/MTBI in the non-deployed setting is based on the Departments of Veteran Affairs and Defense (VA/DoD) Evidence-Based Clinical Practice Guideline for the Management of Concussion/Mild TBI, which was released in April 2009 (Table 6-2). This guideline addresses assessment and treatment after 7 days from the initial injury. It is the primary clinical tool used in Role 4 and 5 settings. The evidence was evaluated and rated based on the US Preventative Task Force Grade definitions (Table 6-2).

Table 6-2: US Evidence Rating of Interventions.

A	A strong recommendation that the clinicians provide the intervention to eligible patients. *Good evidence was found that the intervention improves important health outcomes and concludes that benefits substantially outweigh harm.*
B	A recommendation that clinicians provide (the service) to eligible patients. *At least fair evidence was found that the intervention improves health outcomes and concludes that benefits outweigh harm.*
C	No recommendation for or against the routine provision of the intervention is made. *At least fair evidence was found that the intervention can improve health outcomes, but concludes that the balance of benefits and harms is too close to justify a general recommendation.*
D	Recommendation is made against routinely providing the intervention to patients. *At least fair evidence was found that the intervention is ineffective or that harms outweigh benefits.*
I	The conclusion is that the evidence is insufficient to recommend for or against routinely providing the intervention. *Evidence that the intervention is effective is lacking, or poor quality, or conflicting, and the balance of benefits and harms cannot be determined.*

There are 26 evidence-based recommendations in this document that address early education, patient perception of symptoms, cognitive symptoms, behavioural symptoms, dizziness and disequilibrium, persistent cognitive and behavioural difficulties greater than 4 weeks, physical rehabilitation, laboratory tests and multiple concussions. Please see the Defense Centers of Excellence (DCoE) fact sheet found at (www.dcoe.health.mil) for specifics related to these areas.

The MTBI treatment plan is based on the following:

- Symptom management;
- Education of patient and family;
- Emphasize recovery, gradual resumption of work and social responsibilities;
- Compensatory strategies and environmental modifications;
- Early intervention maximizing use of non-pharmacological therapies;
- Sleep hygiene and relaxation techniques; and
- Minimize consumption of alcohol, caffeine and other stimulants.

6.3.2.5 Symptom Management

6.3.2.5.1 Treatment of Tension-Type Headaches

Non-pharmacological treatment can include relaxation training and biofeedback, in combination with medication, physical therapy and increased physical activity. Pharmacological treatment can include Non-Steroidal Anti-Inflammatory Drugs (NSAIDS), such as Ibuprofen, Naproxen or Acetaminophen.

Medications to be used as prophylactic therapy for 3 or more headaches per week may include Divalproex sodium ER, Topiramate or Metoprolol.

6.3.2.5.2 Treatment of Migraine Headaches

Non-pharmacological treatment can include awareness and avoidance of migraine triggers, relaxation, biofeedback, visualization extra-cranial pressure, cold compress, regular exercise, maintaining regular exercise, sleep and meal schedules, recognize warning signs (aura), and a headache diary. Pharmacological treatment can include Zolmitriptan oral or nasal spray or Sumatriptan oral, nasal spray or injectable. In addition, an analgesic wash-out period may help.

6.3.2.5.3 Treatment of Dizziness or Disequilibrium

Vestibular and balance rehabilitation can offer a non-pharmacologic approach. Pharmacological approaches are not shown to be effective in chronic dizziness after concussion. Consider medications only if symptoms are severe enough to significantly limit functional activities. The following have been used for this purpose: Meclizine, Scopolamine, Dimenhydrinate, Lorazepam, Clonazepam, Diazepam.

6.3.2.5.4 Treatment of Fatigue

Non-pharmacological approaches include well-balanced meals, sleep hygiene, regular exercise and cognitive behavioural therapy. In addition, identifying and treating underlying medical and psychological disorders should

be explored prior to initiation of pharmacological measures. For persistent symptoms (greater than 4 weeks) without improvement of management of sleep, pain, depression, lifestyle, then consider neuro stimulants, including Methylphenidate, Modafanil or Amantadine. The medication trial should be for at least 3 months.

6.3.2.5.5 Treatment of Sleep Dysfunction

Non-pharmacological approaches include sleep hygiene, which is defined as relaxation training, avoiding alcohol, restricting night-time sleep period to about 8 hours, avoiding going to bed too early in the evening, avoiding stimulants during the evening period, waking and rising from bed at regular times in the morning, reducing or eliminating daytime naps, engaging in daytime physical and mental activities, and avoiding stimulating activities before bedtime. Pharmacological approaches can include Zolpidem or Prazosin.

6.3.2.6 Education of Patient and Family

It is strongly recommended that patients who sustain a concussion/MTBI be provided with information and education about symptoms and recovery patterns as soon as possible after the injury. Education should be provided in print with verbal review of symptoms and expected outcome, education that the current symptoms are common and expected after the injury event, and reassurance about the expected positive recovery. It is also recommended that techniques to manage stress (sleep hygiene, relaxation, minimize consumption of alcohol, caffeine or other stimulants) be discussed. Finally, patients should be given written contact information and advised to contact their healthcare provider should symptoms get worse or persist for greater than 4 – 6 weeks.

6.3.2.6.1 Cognitive Symptoms

Early patient and family education may help with managing cognitive complaints. If a pre-injury cognitive evaluation was obtained, a post-injury comparison may be of value. Finally, comprehensive neuropsychological evaluation is not recommended in the first 30 days after injury. Consider cognitive rehabilitation if symptoms persist.

6.3.2.6.2 Behavioural Symptoms

It is strongly recommended that treatment of psychiatric/behavioural symptoms following MTBI/concussion be based upon individual factors, nature and severity of symptom presentation and include psychotherapeutic treatment. In addition, co-morbid psychiatric conditions, whether or not related to the MTBI, should be treated aggressively.

6.3.2.6.3 Physical Rehabilitation

There is no contraindication for return to aerobic, fitness and therapeutic activities following MTBI/concussion. Non-contact, aerobic and therapeutic recreational activities should be encouraged within the limits of the patient's individual symptoms to improve physical, cognitive and behavioural complaints after mild TBI. However if symptoms return after exercise, then a more graded approach to activity should be considered.

There are other treatment recommendations based on management of other symptoms, that include pain, vision and hearing difficulties, olfactory deficits, changes in appetite, numbness and nausea. These can be found in the VA/DoD MTBI Clinical Practice Guideline [5].

6.3.2.7 Clinical Recommendations (CR)

There has been further clinical guidance developed to include the following:

- Guidelines for the Field Management of Combat Related Head Trauma (2006) [140];
- Neurobehavioral Evidence-Based Guidelines for the Treatment in TBI (2006);
- Acute Management of Concussion in the Deployed Setting (2007, 2008, 2010, 2012);
- Cognitive Rehabilitation for Mild TBI (2009);
- Driving Assessments after TBI (2009);
- MTBI and Co-occurring Psychological Health Disorders Tool Kit (2011);
- Neurocognitive Assessment Tool (NCAT) Clinical Recommendation (2011);
- Neuroendocrine dysfunction after mild TBI (2012);
- Clinical Recommendation (CR) for the Detection and Treatment of Dizziness Following TBI (2012);
- CR for the Detection and Referral of Visual Dysfunction Following MTBI (2013);
- CR for progressive return to activity following acute mild TBI in the deployed and non-deployed setting; and
- CR for standardization of neuroimaging in MTBI in the non-deployed setting.

In addition, the following clinical guidance packages are in development and anticipated to be disseminated to the US military health system:

- CR for progressive and graded activity after mild TBI;
- CR to inform the evaluation and treatment approach to sleep disturbances associated with TBI; and
- CR to address post-traumatic headaches following MTBI.

DoD is also focused on identifying effective treatments for MTBI, which may include assessing several potential therapies that are currently Food and Drug Administration (FDA)-approved for other indications as well as investigations into the role and effectiveness of complementary and alternative medicines as part of an integrative health approach model for MTBI. Developing and validating more effective, technology-enhanced cognitive and behavioural rehabilitation tools are also being explored.

6.3.2.8 MTBI and Co-Morbidities

The issue of co-morbidities appears more pronounced in populations with an existing diagnosis of a traumatic brain injury. For example, among service members with a history of MTBI, two large studies found PTSD prevalence at 33% to 39% of service members. Lew [141] found that in a treatment-seeking sample of 340 VA eligible service members, 81.5% reported chronic pain symptoms, 68.2% reported PTSD symptoms, 66.8% reported TBI symptoms and 42.1% reported symptoms of all three. These are now known as the triad of co-occurring conditions with MTBI. Additional symptoms included sleep disorders, substance abuse, psychiatric illness, vestibular disorders, visual disorders, and cognitive disorders. The co-morbidity of PTSD with a history of MTBI, chronic pain and substance abuse is common in the military and complicates recovery from any single condition.

6.3.3 Canada

In 2008, based on an expert advisory panel recommendation, the Canadian Forces Health Services implemented clinical practice guidelines for MTBI sustained in the military operational setting. The over-arching philosophy behind these guidelines is that, for the most part, MTBI is an acute injury which largely recovers over a short time period in the majority of individuals, and is optimally managed by rest and education [142], [143]. Those who present with symptoms months after an injury often represent a complex clinical picture, where multiple factors are at play and it cannot be immediately assumed that symptoms are attributable to MTBI without thorough and thoughtful evaluation [17], [22], [144].

Promulgation of a more systematic approach to the identification and management of suspected cases of MTBI has different goals depending on the deployment phase. During deployment, the immediate goal in all cases of head injury is to identify those who may require neurosurgical consultation. Following this, the primary objective is to identify those with symptoms and/or impairments that may be attributable to MTBI in order to evaluate fitness for duty. Identification and management of MTBI in those who have sustained other injuries is an important consideration, as this may have an impact on the clinical course of their recovery. Modification of post-deployment screening provides surveillance data on MTBI in those who have returned from deployment and also allows for a more systematic approach in identifications and management of persistent symptoms regardless of whether they are attributable to MTBI or other causes.

6.3.3.1 Canadian In-Theatre Guidelines

Although Canada adheres to NATO doctrine in the provision of health-care in deployed settings, MTBI guidelines were not developed by the specific Role/Echelon of health-care.

Two guidelines are in use: the first is intended to be used by medics in more forward areas (see Figure 6-5), while the second is targeted towards primary care providers (see Figure 6-6).

Medical Technician Management of Concussion (mTBI) in a Deployed Setting

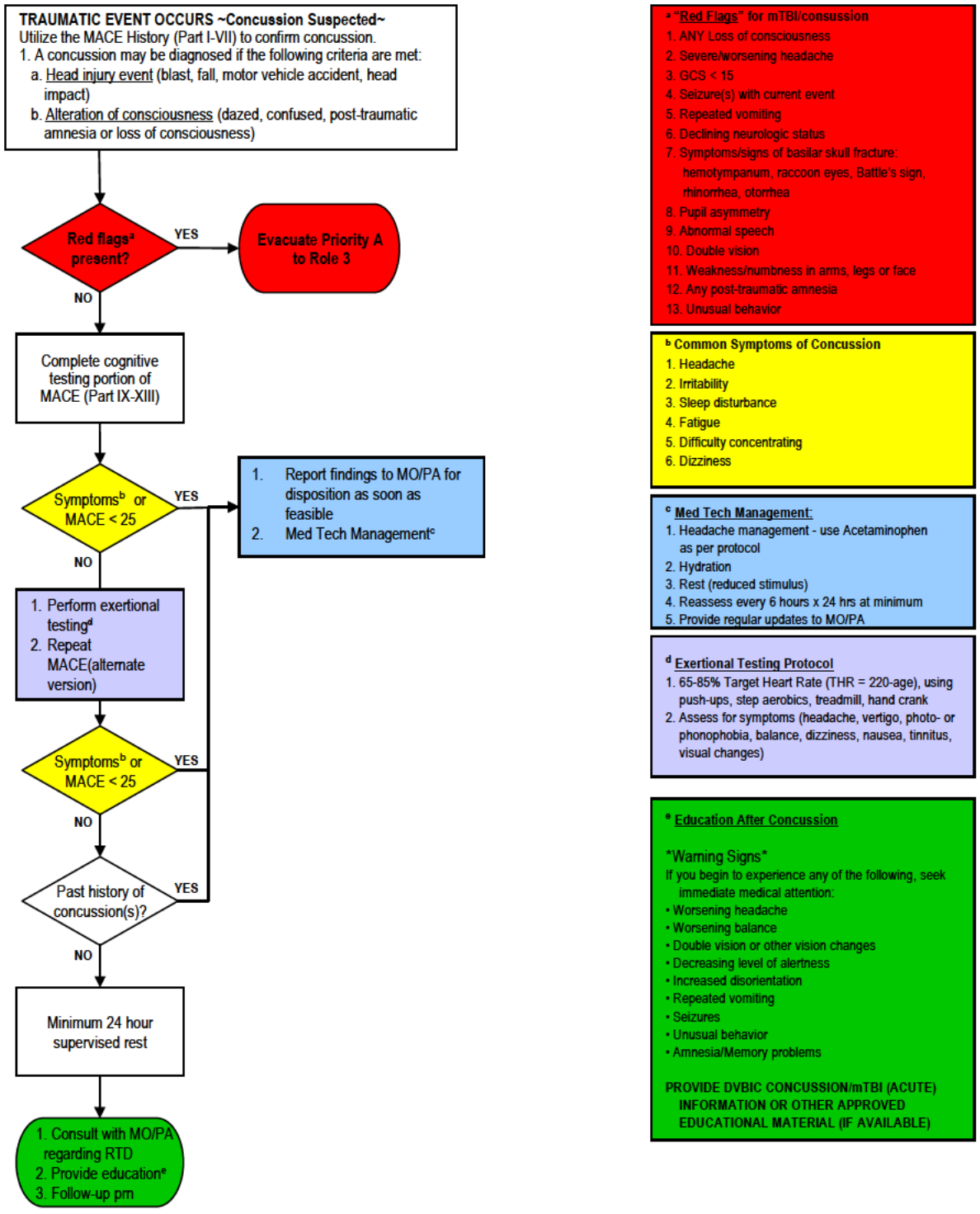

Figure 6-5: Canadian In-Theatre Guidelines for Medical Technicians.

Primary Care Management of Concussion (mTBI) in a Deployed Setting

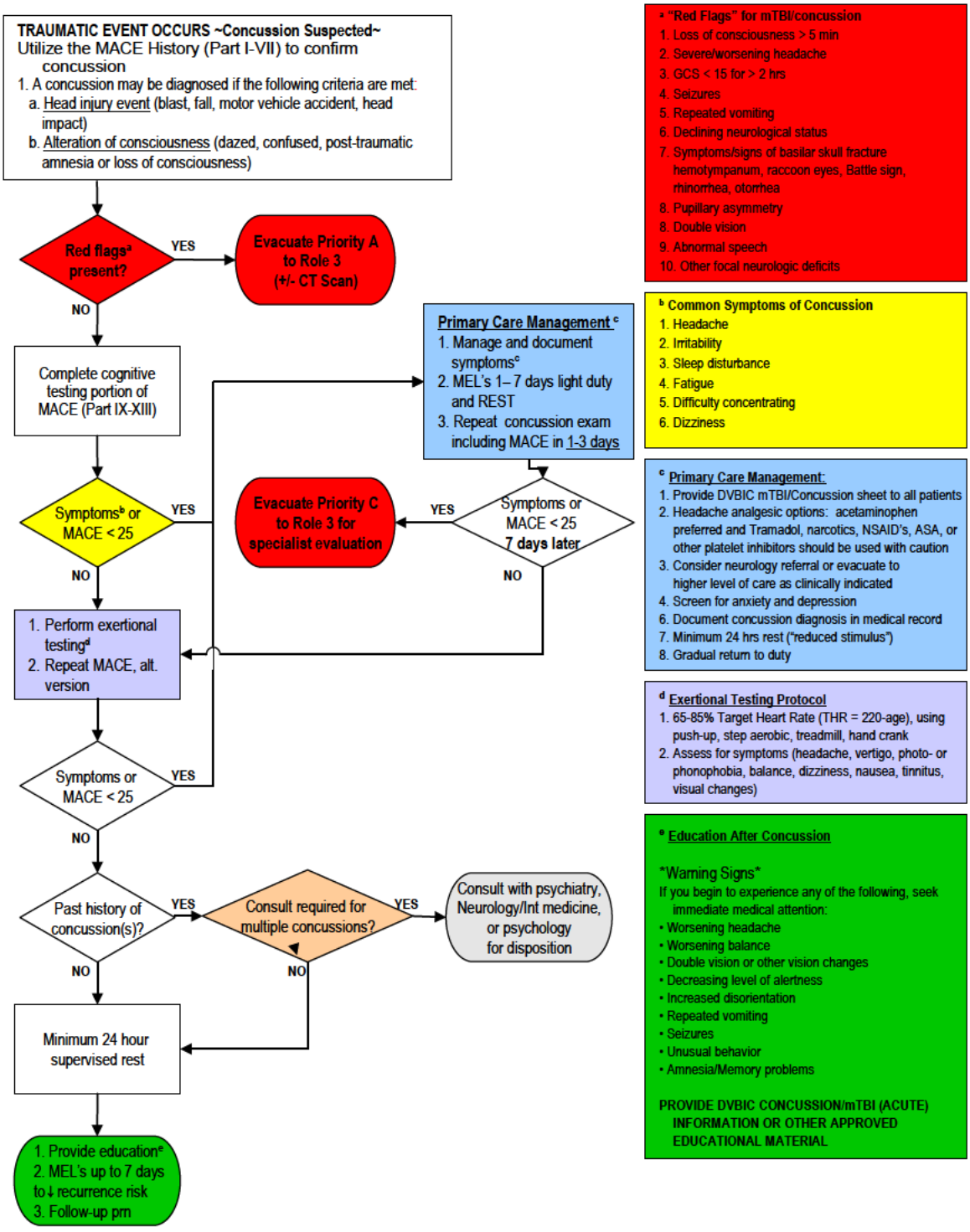

Figure 6-6: Canadian In-Theatre Guidelines for Primary Care Providers.

The US MACE screening tool is the cornerstone of in-theatre evaluation [145]. A version was translated into French. Medical personnel are trained in the use of the MACE prior to deployment (Annex F). The MACE is a two-staged test. The first stage is oriented towards describing the injury event and current symptoms, while the second stage is oriented towards pragmatic bedside testing of attention, concentration and memory. While it is acknowledged that there is limited validation data on the MACE, it is derived from a well-validated assessment of concussion in the sports population, the Standardized Assessment of Concussion (SAC) [146], and use of it by the Canadian Armed Forces allows for comparison to research findings from the US, where it is currently used.

A crucial first step in evaluating anyone suspected of having sustained a head injury is to identify more serious intracranial lesions that require urgent referral for neuroimaging and/or neurosurgical consultation. Consequently, the initial evaluation of those who have a history suspicious of MTBI is focussed on determining whether there are symptoms or signs suggestive of such pathology. To that end, a number of 'red flag' predictors have been incorporated which emanate from both the Ottawa Head CT Rule and New Orleans Rule [147], [148] as advocated in the American College of Emergency Physicians 2008 Guidelines [149]. Although both of these rules have been well validated in a civilian setting, there has never been validation in a combat setting, where predictors such as advanced age or dangerous mechanism of injury are of little use. Moreover, the deployed setting poses special logistical constraints that need to be factored into clinical decision-making, such as the risk of re-injury when transporting from more forward areas for consultation, Until a set of predictive rules are developed and tested in this context, the use of such civilian guidelines is supported by expert opinion, while cognizant of the special circumstances of the deployed environment.

Cognitive testing in assessing fitness for duty is an element of the MACE, but the use of more detailed neuropsychological testing is left to the discretion of the clinician. The use of such testing is widely supported by expert opinion in the sports literature [150]. However, it must be recognized that the incremental value of such tests on clinical decision-making has not been conclusively demonstrated. To date, the use of such tests in determining fitness for duty in a military operational context has not been scientifically validated. Moreover, even though a number of clinician-administered neuropsychological tests have been employed in research, there is no consensus on what clinician-administered tests alone or in combination are best suited for diagnostic and return to play assessments [143]. Noting many important differences between the playing field and the battlefield when it comes to administering, interpreting, and reacting to such tests, the Canadian Armed Forces Expert Panel has adopted an individualized approach to the use of such testing by clinicians.

There has been increasing attention on the possible impact of multiple concussions, and a consideration of this is important in any return-to-duty decisions. Unfortunately, while the effect of a single concussion on cognitive measures has been relatively well studied, data on the impact of multiple concussions presents conflicting results [150]. In consideration of this, management of multiple concussions is not based on a predefined number of prior concussions. Instead, it is based on an individualized approach that takes into account a number of modifying factors, including:

1) Repeated concussions over time;
2) Injuries close together in time;
3) Recent concussions and repeated concussions occurring with progressively less impact or force;
4) Slower recovery after each successive concussion; and
5) The absolute risk of subsequent concussions [150].

A minimum 24-hour rest period is mandated for individuals who likely had a concussion by history but are asymptomatic and have a normal MACE before and after exertional testing. This recommendation was based on

Canadian Armed Forces medical expert opinion in light of current guidelines for return to play in sports concussion. The goals of this minimum rest period are:

1) To facilitate attentive observation for manifestations of delayed intracranial haemorrhage during the period of greatest risk;
2) To permit a period of physical and cognitive rest, which may hasten resolution of post-concussive symptoms and hence promote an earlier return to full duties; and
3) To decrease the risk of a second concussion (and a potentially more complicated post-concussive course) during the period of greatest risk.

In the sports concussion context, current guidelines emphasize rest until symptoms resolve, followed by a graded program of exertion over a period of 5 to 7 days prior to medical clearance and return to play [10], [150]. Same-day return to play is supported in sports concussion in ideal circumstances [9], [151], [152]. In both instances, neither approach is strongly evidence-based. There are important differences between military concussions sustained in the operational setting and sports concussions sustained on the playing field.

Education on the guidelines for medical staff emphasizes that the 24-hour rest period is just a minimum: many concussed individuals will end up being provided significantly longer periods of rest until they are free of symptoms on exertion and have a normal neurocognitive exam results, using the MACE.

6.3.3.2 Post-Deployment Guidelines

Provision of MTBI care in a Role 4 setting is contained in the post-deployment guidelines. The underlying philosophy of these guidelines is provided below, and the guidelines are contained in Figure 6-7.

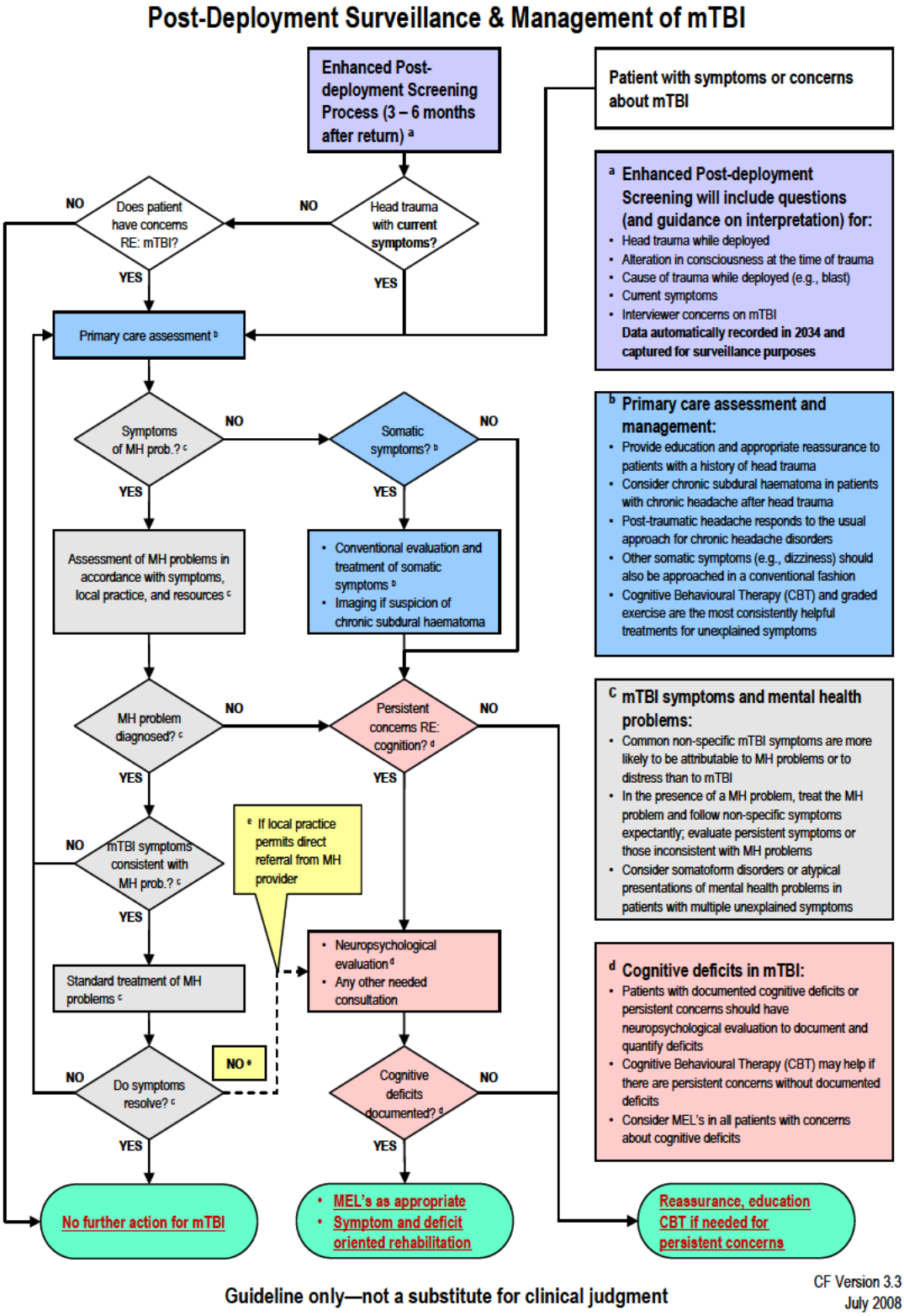

Figure 6-7: Canadian Post-Deployment Guidelines.

Those who experience a multitude of symptoms many months following a history of deployment-related MTBI present a complex clinical picture. Soldiers who have returned from deployment to a combat zone frequently experience ill health from a variety of causes, many of which are not well understood. There is abundant data that shows that an important minority of soldiers returning from combat experience psychological illnesses such as PTSD, depression and substance abuse [18]-[20]. Others experience a variety of medically unexplained physical symptoms, an observation that initially emanated from Gulf War I, but is now largely recognized to have existed even before that particular conflict [153]. The diagnostic dilemma is further compounded by the fact that post-concussive symptoms are common in the general population and are non-specific [17]. Faced with a history of possible concussion during the deployment, the clinician is well advised not to assume that any current symptoms are a consequence of persistent neurologic injury.

The best scientific studies in the sports literature (primarily dealing with impact injuries) suggest that in the majority of cases of MTBI, symptoms and measurable neurological deficits resolve within a week [142], [154], and most other studies show resolution within a few weeks to months [22]. Although it was postulated that the clinical course of MTBI following primary blast wave exposure might differ from impact injuries, the evidence to date has not supported this assertion [155].

A minority of cases of civilian MTBI have persistent symptoms [15]. The more common of these symptoms often occur together and have been given varying terms such as post-concussion syndrome or post-concussion disorder [16]. There is little uniformity in the identification of predictors of delayed recovery after MTBI [15], because there is little consistency in the predictors studied and an absence of confirmatory studies. Moreover, the symptoms that may occur following concussion (e.g., headache, dizziness, fatigue, irritability, insomnia, memory or concentration difficulties) can overlap with symptoms of other conditions, further complicating the ability to attribute symptoms to a specific cause. This has been demonstrated in at least one prospective study in a civilian trauma population that showed that the prevalence of such symptoms was equivalent in trauma patients with and without head injury [17].

Within the military context, PTSD and depression are important mediators of the relationship between mild traumatic brain injury and physical health outcomes. A seminal study was published in 2008 that looked at health outcomes in US Army Infantry Soldiers 3 – 4 months after deployment [22]. The authors found that soldiers with mild traumatic brain injury, primarily those who had loss of consciousness, were significantly more likely to report poor general health, missed work days, medical visits, and a higher number of somatic and post-concussive symptoms that soldiers with other injuries. However, after adjustment for PTSD and depression, mild traumatic brain injury was no longer significantly associated with these physical health outcomes or symptoms, except for headache. Since then, four peer-reviewed publications, as well as our own unpublished analysis of Canadian Armed Forces personnel 3 – 6 months after deployment, have confirmed the observation that persistent symptoms following a history of MTBI in a military operational setting are almost entirely accounted for by the presence of a mental health diagnosis such as PTSD or depression [25], [68], [156], [157].

Moreover, there are few MTBI-specific therapies that have been shown to be efficacious for the treatment of persistent symptoms following concussion. A critical appraisal of the literature has shown that the majority of interventional studies employed weak methodologies [36], [158]. There is good evidence that early educational interventions that include reassuring information about the high probability of a good recovery and advice and encouragement on gradual return to regular activities helps improve symptoms in patients with MTBI [159].

Based on the preceding considerations, in 2008, the Canadian Armed Forces (CAF) advisory panel developed a strategy for the management of those with post-deployment symptoms following a history of in-theatre MTBI (see Figure 6-7). The pillars of this strategy are as follows:

- It is primary care centric, as opposed to specialty care centric;
- Given the high prevalence of mental health disorders in the post-deployment population, these are screened for and aggressively treated when present; and
- Late symptoms are managed using a symptom-based diagnostic and treatment approach, with application of symptom-specific evidence based treatments where possible.

While this strategy represented a unique approach when developed by the CAF advisory panel in 2008, the Ontario Neurotrauma Foundation has since independently published guidelines endorsing a symptom-based approach for post-concussive symptoms following a critical appraisal of the literature [160].

6.3.4 Netherlands

6.3.4.1 Netherlands In-Theatre Protocol

Based on increasing reports in the literature regarding MTBI following blast exposure, a 'Blast Tracking Database' was implemented which used helmet implanted blast dosimeters. Careful reporting of blasts occurrence as well as screening of blast exposed soldiers was considered essential to evaluate symptom onset and long-term effects.

A good assessment is essential to guarantee the health and availability of soldiers during deployment. The use of the Military Acute Concussion Evaluation (MACE) provided a structured opportunity for assessment of the effects of blast on the health of the individual and the troops. The MACE was conducted by specially trained personnel. From November 2009 until the end of Dutch participation in ISAF in Uruzgan, approximately 110 MACEs have been administered. Although the Netherlands adheres to NATO doctrine in the provision of health-care in deployed settings, and in line with other forces, MTBI guidelines were not developed by the specific Role/Echelon of health-care. Two guidelines are in use: the first is intended to be used by medics in more forward areas, while the second was targeted towards primary care providers.

So the US MACE screening tool was used as cornerstone of in-theatre evaluation [148]. A version was translated into Dutch. Medical personnel were trained in the use of the MACE prior to deployment. The MACE is a two-staged assessment. The first stage is oriented towards describing the injury event and current symptoms, while the second stage is oriented towards pragmatic bedside testing of attention, concentration and memory. It was acknowledged that there is limited validation data on the MACE, and use of it by the Netherlands Forces allows for comparison to research findings from the United States, as well as other forces using the instrument.

Cognitive testing in assessing fitness for duty is an element of the MACE, but the use of more detailed neuropsychological testing was left to the discretion of the clinician. The use of such testing is widely supported by expert opinion in the literature. However, it must be recognized that the incremental value of such tests on clinical decision-making has not been conclusively demonstrated. To date, the use of such tests in determining fitness for duty in a military operational context has also not been scientifically validated.

A minimum 24-hour rest period was mandated for individuals who likely had a concussion by history but were asymptomatic and had a normal MACE. Education on the guidelines for medical staff emphasizes that the 24-hour rest period was a minimum: many concussed individuals ended up being provided significantly longer periods of rest until they are free of symptoms and had a normal neurocognitive exam results, using the MACE.

6.3.4.2 Post-Deployment Protocol

All blast-exposed individuals were screened again at 3 and 12 months post-deployment. The assessment included screening for symptoms of PTSD, as well as for symptoms of fatigue and extensive neurocognitive testing. If symptoms persisted individuals were referred for treatment.

This protocol included good care as well a component of research. The goal of screening was to detect and treat individuals who had persistent symptoms of MTBI following deployment. The purpose of the research component was a picture of the epidemiology of health problems associated with blast exposure, evaluated and adjusted for the purpose of precautionary screening protocols and return.

For the above objective, implementation of MACE in theatre area:

1) **During Deployment**: Role 1/2. During the mission, all soldiers who were exposed to a blast had a MACE assessment completed by the GP, AMA or AMV and entered into the Defence Medical Information System (GUIDE).
2) **After Return**: Military Rehabilitation Centre. A return screening protocol prepared in cooperation between the disciplines of neurology, psychiatry, rehabilitation medicine. The return was a screening 3 months and 12 months after deployment. If symptoms were present on screening, then the individual was referred to the most appropriate medical specialist. Soldiers exposed to blast prior to the implementation of this protocol in 2009 were also assessed if they self-reported symptoms, but this assessment was not mandatory.

This screening was additional to and independent of the standard Behavioral Health Screener that is conducted 6 months after return.

Timeline and Implementation

1) **Pre-Deployment**: Approximately 2 – 4 weeks before departure; 2 hours of MACE training was given to medical personnel.
2) **Initial Assessment**: During deployment, in-theatre assessment by the medical officer takes place; in accordance with registration guidelines and criteria.
3) **Second Assessment**: Post-deployment I, about 8 – 12 weeks after return; all soldiers that were exposed to blast who were screened in-theatre by MACE.
4) **Third Assessment**: Post-deployment II, 12 months after return (or sooner if person leaves military).

Table 6-3: Details and Timelines of Dutch MTBI Assessment Protocol.

	First Assessment	Second Assessment	Third Assessment
When	Within 24 – 48 hours after the incident	Three months after returning from theatre	A year after the incident
What	Screening for brain injury and physical symptoms	Screening for PTSD and brain injury and physical complaints	Screening on PTSD
How	MACE Assessment and physical examination *Cave: hearing*	MACE/short NPA, Impact Events Scale, 4DKL, fatigue Assessment and physical examination *Cave: hearing*	TBD – Impact Events Scale, 4DKL, fatigue
Where	In theatre	MRC	MRC
Who	Physician, or trained nurse	Physician assistant	Physician assistant
Record	Sent to MRC	Archive MRC	Archive MRC

This research was coordinated by the MRC in Doorn, Military Mental Health and Central Military Hospital.

The Role of the Military Rehabilitation Centre in the Screening of IED

In the flowchart around the screening of those involved in an IED incident, was a role for the Military Rehabilitation Center. In the screening, three months after return home, the Military Rehabilitation took the lead.

This section shows how this part of the screening was designed:

a) Notification, registration of candidates for the screening was by invitation based on in-theater MACE lists. These soldiers received an invitation to the Military Rehabilitation Center (MRC). The soldier was then enrolled in the Military Rehabilitation. In case of absence of a response, a request was made on their Commander.

b) Nature and type of research – the entire examination took about 90 minutes and was aimed to detect any physical, cognitive or psychological problems. There was first a brief history by a physician, followed by a series of short tests that were conducted by a research assistant, and reviewed and debriefed by a neuropsychologist.

c) Following the findings of the investigations the next steps could include:
   - No evidence of any problem: no follow-up action;
   - Evidence of a physical problem: referral by the MRC to the appropriate medical specialist, e.g. to the neurology clinic;
   - Evidence of a cognitive problem: There is a more extensive neuropsychological testing; and
   - Evidence of PTSD or other psychiatric/psychological problems: Referral to MMH Utrecht place.

d) Processing of all the test data was performed at the Military Rehabilitation. The data was shared with the staff of the MMH, CMH or outpatient neurology. A letter was sent to provide feedback to the medical unit of the military.

Advantages and Disadvantages

Advantages for the individual soldier – screening and monitoring for possible health effects of blast exposure:

- Benefits for military organization;
- Evidence-based policy on blast effects;
- Availability of good data on development and follow up of health effects of blast;
- Health monitoring;
- Barriers for participating soldiers;
- Three screening interventions, including questionnaire (10 min) and clinical visits MRC Doorn; and
- Risk of stigmatization or not presenting problems (medicalization/iatrogenic injury).

The MACE is a good, useful assessment, seemingly most important for phase one, which contains careful history assessment as well as assessment of consciousness and first symptoms. However, the MACE lacks specificity and the scale is not validated. Yet, its use in theatre may prevent retrospective bias when patients present with symptoms later.

At Follow-Up (FU), after 3 – 6 months most soldiers volunteered to report that they were very satisfied with the assessment. It was remarkable that almost all of the soldiers that were reassessed at FU had no complaints. At this moment of assessment we could not find evidence of discrete mTBI (yet) by self-reported symptoms. Yet a significant portion of the studied population had a very weak performance on the neuropsychological battery that was used, in particular information processing and memory performance. This finding could be explained by several factors. First, the fact that they all were blast exposed, and so that the effect we measured was attributable to the blast. Several studies hypothesize a direct effect of blast on neurocircuitry involved in these processes. Secondly, it could be a secondary phenomenon. The soldiers could have scored low on these parameters pre-deployment. The Dutch military does not routinely screen with a neuropsychological performance assessment, or does this as standard screen prior to deployment. Other military services, e.g., the United States Army, use the ANAM in a militarized version to assess neuropsychological performance prior to deployment. We have tried to overcome the absence of a pre-deployment neuropsychological assessment by the comparison with a properly designed control group. This control group has been deployed in the same period, and is selected on the criterion of being in a treat. We chose a group which experienced a threatening event to control to what extent the psychological element of the blast incidence accounts for mTBI symptoms and cognitive performance. The criterion was based on questions in the aftercare research of the Dutch army completed 6 months after deployment. We included those who experienced a threat on the scale of sometimes to very often. However, the control group was tested once at the timing of the last screening of the blast group, being 12 – 18 months after deployment. We admit that this caused some problems with the interpretation of our results. A possible learning effect that could have occurred in the test group by the repetitive screening was absent in the control group. The late timing of testing could give an incomplete picture of the deployment stress because symptoms could have diminished over time.

Thirdly, demand characteristics could also contribute to the results. It could well be that participants were nervous, which contributed to a demand characteristic in which their performance was compromised. This could

have happened in the first screening of not only the blast group, but also during the single test of the control group.

Also it remains ambiguous if the neuropsychological tests are the best method for screening for long-term mTBI symptoms. Sustaining symptoms after concussion longer than 3 months are called post-concussive symptoms or post-concussive syndrome. It remains unclear how the blast mTBI symptoms evolve, in cases where they persist, they may be similar to post-concussive symptoms. Little research has been performed in blast-related post-concussive symptoms – but the few that existed provided us with interesting information. Brenner et al. (2010) tested 45 participants with and without sustaining mTBI symptoms on several neuropsychological tests. The conducted tests included the Stroop task and symbol digit task, which were also part of our research. They compared the outcomes of 27 soldiers with sustaining mTBI symptoms and 18 without. On the total of all tests were no significant effects, the Stroop and symbol digit modality task also did not show effects separately. These findings were supported by earlier self-reported mTBI versus post-concussive symptoms research which indicated that a history of symptoms did not increase the risk of poor performance on ANAM [73].

We concluded that careful reporting (e.g., in an electronic data reporting system) during a sustained blast exposure and targeted screening is essential to evaluate immediate impact and evaluate long-term effects. Of key importance is the implementation of a 'Blast Tracking Database' as well as a 'Wounded in Action' database (e.g., how many blasts, how many soldiers exposed, injured) in following up on the health and operational fitness of those that are injured (according to one of the recommendations of literature). This information can be difficult to obtain during combat operations, particularly since some of it may be classified. However, such information, together with helmet blast dosimeter data, would be extremely useful in order to better establish the potential health impacts of blast exposure.

Although the first signs of blast-induced neurotrauma usually appear immediately, it can sometimes take months or years after the initial trauma before they manifest. These are vague symptoms like extreme fatigue, attention and concentration problems, memory problems, irritability, insomnia, tinnitus, and mood swings. The wide variety of symptoms includes weight loss, hormonal problems, chronic fatigue, headaches and memory problems, speech and balance problems. These changes are often debilitating and slowly but surely start to interfere with daily activities. Because these complaints are underestimated, time is lost for secondary prevention and/or timely rehabilitation. It is unclear what component of the blast carries more impact on health and operational fitness in the longer term: physical, emotional or neuropsychological aspects.

In PTSD it is known that there is an autonomic dysregulation (manifesting in disorders of cognitive and emotional disinhibition, sleep and arousal) that drives the symptoms in the disorder. The neurobiological correlates are known, and the central and peripheral dysregulation has been well studied. This is also very well known in moderate and severe TBIs, but not yet sufficiently studied in the mild forms of TBI. There are candidate biomarkers, proteomics, for TBI (the UCH-L1 protein, MAP-2, and tau) which have the potential to establish a diagnosis of MTBI, particularly in milder forms. However, none of these have any proven diagnostic or prognostic value at this time.

In summary, careful reporting of effects of blast exposure through targeted screening is essential to evaluate symptom onset and long-term effects. Implementation of the MACE as a screening instrument for traumatic brain injury, as well as post-traumatic cognitive symptoms, can provide an opportunity for structured assessment of the effects of blast on the health and operational fitness of the individual soldier. Importantly, they should also contribute with guidelines to line Commanders when to call for return-to-duty when soldiers are exposed to an IED-related blast. Yet, we felt that there are still gaps in knowledge that prevent us from a complete and definite answer to the long-time impact of blast exposure on deployed soldiers. The outstanding research efforts that have been initiated over the last 5 years carry high expectations of being able to resolve at least some of these.

Chapter 7 – RESEARCH ON BLAST-INDUCED INJURIES WITH SPECIAL REFERENCE TO MTBI OR MILD BLAST-INDUCED NEUROTRAUMA

Mårten Risling

7.1 INTRODUCTION

The relationship between detonations and alterations in the function of the brain has been a concern since World War I. The large battles in Flanders generated enormous numbers of injuries and stress reactions. The distinction between neurological injuries and psychiatric disorders initiated by scenes at the battlefield created an intense debate at the time. It is still not fully clear whether the Shell-Shock syndrome should be regarded as a Post-Traumatic Stress Disorder (PTSD), a separate type of combat stress reaction, or as a somatic reaction to blast waves, i.e., a blast-induced traumatic brain injury [13]. The use of Improvised Explosive Devices (IED) in modern asymmetric warfare and terrorism has resulted in a growing number of soldiers and civilians that have either been directly exposed to blast waves or that suffer from the indirect effects of a blast [161]. The improved body and vehicle protection has evidently changed the scene significantly. Many of the individuals that are exposed to blasts today would probably have received lethal injuries had they not been protected by such armour. However, modern protection may also possibly change the conditions for blast propagation in the body. For example, if the duration of a blast wave or the time to achieve peak blast pressure is changed, it may alter the injury pattern. Lessons can probably be learnt from the studies on BABT (Behind Armor Blunt Trauma) [162], [163]. The first experimental studies on the biological effects of blast waves were published more than 60 years ago [164]. Fundamental information about the propagation of blast waves in the body, as well as their effects, is still absent today. However, recent studies have provided important knowledge about the distribution of inflammatory reactions after blasts, in connection to body armour [165].

Traumatic Brain Injury (TBI) is a very complex entity, often complicated by secondary injury cascades. Mild TBI is the dominating group of TBI. Most cases of mild TBI probably have very limited physical lesions, if any. Recent diffusion tensor imaging findings in MTBI are more promising to capture physical lesions [45]. However, many have functional effects that last for a considerable amount of time, and the underlying factors remain to be established. The physics of blast injury are very different compared to trauma that occurs within the usual civilian setting. Blast-induced brain injuries are often referred to as Blast-Induced Neurotrauma (BINT) and this term may also include spinal injuries.

One way to understand the effects of a blast wave is to divide the mechanism into:

- **Effects of the Primary Blast Wave:** The propagation of a supersonic pressure, transient, with short duration. The threshold for injuries is determined by factors such as peak pressure, duration and shape of the wave (reflections, underpressure, etc.). The effects, such as bleeding in air-filled organs including the lungs and ears are well known, but the potential effects upon the central nervous system are still debated. For simple wave forms, i.e., the Friedländer type of wave, dose-response curves (the Bowen curves) have been determined [166]-[170].
- **Secondary Effects of Blast:** Due to the impact of flying objects, such as shrapnel fragments, which can generate penetrating injuries. The proportion of such injuries was larger in previous conflicts, but seems to have been reduced by improvements in helmet construction. Outcome data from a large cohort of patients that survived penetrating brain injuries is available through the Vietnam Head injury study

[171]. This is probably the most detailed follow-up neurotrauma study that has ever been conducted, and it could serve as model for how useful data should be collected.

- **Tertiary Effects of Blast**: The result of acceleration movements that may result in tissue shearing and diffuse injuries, such as Diffuse Axonal Injuries (DAI).
- **Quaternary Effects of Blast**: The result of light, acoustic, thermal, and electromagnetic energies, as well as toxic fumes. The relative contribution of each of these forces to blast injuries is uncertain [38].

7.2 BRIEF SUMMARY OF OBSERVATIONS IN CLINICAL CASES

The majority of the blast injury cases from the battlefield have sustained a trauma composed of more than one of these aforementioned blast injury mechanisms, e.g., primary blast combined with acceleration movements. However, exposure data are usually not available. Ongoing tests with acceleration sensor probes may change that situation. Severe blast-related TBI with brain edema and vascular spasm could be assumed to be the result of a combination of more than one injury mechanism [172]. The possible vascular propagation of blast waves into the brain and the possible effects on the functioning and perfusion of the blood-brain barrier has been suggested to be an important mechanism for blast [173]. It has been widely discussed whether mild blast-induced TBI should be regarded as a classic post-concussion syndrome or as a separate condition [12], [174].

Given the highly stressful context in which blast injury occurs, psychiatric co-morbidities appear to be over-represented in veterans [175], [176]. Veterans with histories of mild blast-induced TBI have been exposed to more explosions and were more likely to have headaches, features of migraine, more severe pain, PTSD, impaired sleep with nightmares, and neurocognitive impairments [177]. Depression has recently been reported to be more common in female than male veterans suffering from effects of blast-induced TBI [178]. Blast-induced TBIs have negative consequences on service members' perception of health at 6 months post-injury [77]. This co-occurrence of psychiatric disorders can significantly complicate the diagnosis of MTBI and influence the outcome [176]. Moreover, these patients frequently have other serious injuries (such as traumatic limb amputation and hemorrhagic shock) that require aggressive therapies, whose impact on MTBI need to be clarified [38]. Furthermore, hearing, vision and olfaction impairments are not uncommon after blast-induced TBI [141], [177]. Eardrum perforation and tinnitus has been reported in large numbers in veterans exposed to blast [77], [179]. Mild blast-induced TBI patients have a higher proportion of hearing impairment compared to sports induced concussion [180]. Also, disturbance in vestibular function has been observed in veterans exposed to blast [181]. The possibility that mild blast-related TBI may also induce diffuse injuries such as DAI will most likely be evaluated in more detail through the use of modern imaging techniques, such as MRI with Diffusion Tensor Imaging (DTI) protocols [65]. Recently, mild blast-induced TBI was shown to be associated with a diffuse, global pattern of disrupted white matter integrity, not affected by previous civilian MTBI, suggesting a potential difference in the mechanism of action between the types of MTBI [182]. Although available data thus far is not extensive enough to make any conclusions, several recent cohort studies may suggest an alteration of brain function. Veterans experiencing a major depressive disorder following blast showed hyperactivity of emotion processing circuitry [183]. Despite an absence of cognitive deficits, blast-induced MTBI military patients exhibited a diminished interhemispheric coordination of brain activity, which was not the consequence of combat-stress symptoms (PTSD or depression) or commonly prescribed medications [184]. Regional brain hypometabolism was reported after multiple episodes of blast exposure MTBI and persistent post-concussive symptoms. Those veterans, with or without PTSD, also exhibited cognitive domain deficits (i.e., processing speed, attention, working memory, and verbal fluency), and behavioural symptoms (i.e., irritability, poor frustration tolerance, mood swings, getting into fights, and disinhibition), similar to those reported for patients

with cerebellar pathology [185]. These findings are substantial because, in Iraq and Afghanistan, repeated blast exposure may occur within a short period of time: as high as 20% within 2 weeks and 87% within 3 months of the first event [186]. Moreover, an estimated 3,000 MTBI veterans will develop post-traumatic epilepsy [187]. Furthermore, the possibility that multiple MTBI after-blast exposures could induce long-term effects such as dementia should be considered [188] in carefully performed epidemiological studies.

7.3 BRIEF SUMMARY OF STRATEGIES FOR EXPERIMENTAL STUDIES

Epidemiological data do not contain information regarding the relative importance of different blast mechanisms. It is therefore important to generate data in carefully designed animal models. Such models can be selective reproductions of a primary blast, penetrating injuries from fragments, acceleration movements, or combinations of such mechanisms. It is of crucial importance that the physical parameters of the employed models are well characterized so that the experiments can be reproduced in different laboratory settings. Ideally, pressure recordings should be calibrated by using the same equipment in several laboratories. The majority of prior experimental studies have focused on effects of primary blast. A large number of different test situations have been employed. Tube systems with air overpressure chambers are common. Most shock and blast tubes used in current TBI animal models deal with the ideal primary blast wave, but lack the complexity of the real blast generated by an IED on the battlefield [189]. However, there appears to be a lack of consensus with regard to how the pressure in the various exposure systems should be measured and calibrated. Peak pressure and duration should be important components. However, to obtain pressure curves in different parts of the skull and body cavities with sensors that do not interfere with the propagation of the pressure waves is difficult [190]. An experimental animal or a dummy is exposed to overpressure by a controlled perforation of a membrane that is a part of the air overpressure chamber. A few systems are specifically constructed to create complex waves and aim to mimic the specific signatures of different types of explosives or the situation in a protected vehicle [170]. It is also possible to add body protection to the animals to evaluate systemic and regional effects of the blast [165]. Other systems employ real explosives that usually add some quaternary blast components to the experiment. Some experimental set-ups provide a more rigorous control of acceleration movements, to decrease tertiary blast effects. Conclusions from those type of studies indicate that DAI is a feature of acceleration movements rather than a typical effect from primary blast [191].

In most animal models of TBI, active astrogliosis, especially in the hippocampal regions of the brain, seem to be a common pathology – but whether this is caused by inflammation or it causes inflammation in the brain is not clear. Similar to a variety of neurodegenerative diseases, glutamate excitotoxicity has been implicated in various models of TBI [192]. Most recently, it has been shown that the cell surface expression of glutamate receptors, particularly the AMPA sub-types, was greatly changed after blast-induced TBI in rat front cortex and hippocampus [193], [194]. The cellular mechanisms that occur after ear injuries have been analyzed after blasts [195]. However, the extent of cell death in the brain varies in different systems as well as under similar conditions in the same blast tube [191], [196]. Therefore, the contribution of degeneration in mild blast TBI has yet to be settled. The impact of stress reactions on behavioural changes and modifications to injury markers after blasts has been evaluated in a rat model [197]. Moreover, repeated blast exposures may increase neurological impairments [193]. Thus, in summary, data from a number of animal studies seem to indicate that a systemic inflammatory response and delayed stress reactions may be an outcome from primary blasts. The number of experimental studies on blast TBI is rapidly growing and it is not possible to provide a full coverage in this context.

7.3.1 Examples of Models for Blast

7.3.1.1 Open Field Exposure

Examples here are the large-scale classical experiments from the US in desert areas and ponds, employing large sets of animals of different species and sizes. These experiments determined thresholds for bleeding in air-filled organs, such as the lungs and intestines. The potential effects on the central nervous system were, however, not assessed. For simple wave forms, i.e., the Friedländer type of wave, dose-response curves (the Bowen curves) were determined [166]-[170]. Outdoor conditions limit control of the physiology of experimental animals, and may prevent the proper tissue collection that is necessary for detailed studies on the brain. However, open field experiments may allow for realistic experiments with large animals, and waveforms may be very relevant for simulation of IED. New models employing modified open field exposures include a combat zone-like blast scenery for mice [198] and a primate model [199].

7.3.1.2 Blast Tubes for Explosives

During the 1950s, large-sized blast tubes were created to study how construction details such as doors could withstand a blast wave that could correspond to that arising from a nuclear detonation. However, the studies by Clemedson at the Swedish FOA (Swedish Defence Research Establishment) using a smaller blast tube [200], in which a charge of plastic explosive had biological effects from conventional explosions in focus. Clemedson and his co-workers published a number of studies on the vascular and respiratory effects of blast [201], [202]. After some time, this work was extended to include the central nervous system [203] and the cerebral vasculature [204]. In their study, animals were mounted in metallic nets or fixed to body protection in order to limit acceleration movements and limit fragment injuries. Therefore, secondary and tertiary blast effects were very limited in this model. However, smoke and gas emission would continue to contribute as quaternary blast effects. One limitation of the model is the short duration and very simple form of the blast wave. It is possible to modify the blast wave by extending the length of the tube and/or by adding reflective obstacles within the tube. Another modification would be to allow for pre-determined acceleration. Recently, the Walter Reed Army Institute of Research has published interesting studies on mild BINT in swine exposed in a large-size blast tube [205], [206].

7.3.1.3 Shock Tubes with Compressed Air or Gas

Systems with compressed air were used already in the 1950s [207]. Most of these systems comprise 2 chambers, separated by a membrane. Compressed gas is loaded into one of these chambers, referred to the overpressure chamber or the driver section, which is separated from the other chamber, referred to as the main section or the driven section, by a diaphragm. The object (i.e., the experimental animal) is positioned somewhere in the main section. The operator can rupture the diaphragm and the compressed gas enters the main section, and simulates a propagating blast wave. This main section is usually several meters long. If several overpressure chambers are positioned in a series, rather complex waveforms can be created. The duration of the pulse is usually longer and the peak pressure is much lower than in the Clemedson tube. One advantage associated with this type of shock tube is the absence of quaternary blast effects as well as other disadvantages of explosives. However, this advantage can also be regarded as a disadvantage. There are a number of modifications of the shock tube design, and there seems to be a need to calibrate the different systems. Well-documented modern shock tubes can, for instance, be found at the Walter Reed Institute of Research [208] and the US Naval Medical Research Center [209], [210]. In Canada, DRDC Suffield has established a small shock tube within their blast injury program, for the study of blast-induced TBI in small animals. This tube is designed to generate only the primary overpressure wave. It remains to be seen if this overpressure will cause brain damage. Another very

sophisticated shock tube system, capable of reproducing complex shock wave signatures seen in theatre, has been installed at the Applied Physics Laboratory at Johns Hopkins University [170].

7.3.1.4 Models for Penetrating TBI, with Possible Relevance for Secondary Blast

The penetrating ballistic brain injury model includes both the permanent injury tract created by the path of the bullet itself, and the large temporary cavity generated by energy dissipation from a penetrating missile. This model has been characterized in a large number of studies, and can presumably generate important knowledge about cavity formation during fragment penetration, although the model was specifically constructed to simulate effects of NATO 7.62 mm rounds [211], [212] and was not intended for studies on MTBI. Another device for studies on penetration of the skull and brain tissue by shrapnel fragments is the model for controlled penetrating TBI, at a speed of 100 m/s. In this model, a lead bullet is accelerated by air pressure in a specially designed rifle, and the bullet impacts a secondary projectile [213]. The base of the projectile is surrounded by compressible ring that provides control of the penetration depth into the brain. However, this is not a model intended for mild blast TBI.

7.3.1.5 Models for Acceleration/Deceleration TBI, with Possible Relevance for Tertiary Blast

The rotational weight drop model that was developed by Marmarou and co-workers [214], [215] has generated very important data on development of diffuse brain injuries, including an improved understanding of Diffuse Axonal Injury (DAI) [216]. However, this model combines DAI with a contusion injury, which makes the model less useful for selective studies on DAI. A number of acceleration devices have been developed for work on rodents, but the majority of studies seem to result in more severe injuries with meningeal bleeding [217]. A model intended for threshold studies was recently described by Davidsson [218]. The signature injury with this model is a diffuse axonal injury in the corpus callosum, subcortical white matter and/or the brain stem. The absence of cell death and excessive bleeding indicates that this is a mild TBI, and effects on behaviour are limited. Thus, this model can add knowledge about mechanisms and thresholds for acceleration-induced MTBI, and such data can be relevant for the understanding of consequences of tertiary blast.

7.3.2 Animal Species and Strains

The choice of the animal species or strain can obviously have a significant impact on the outcome of the injury. Differences in body size and skull geometry can be assumed to represent critical factors in experimental design. For example, experiments with rotational acceleration are very dependent on the distance to the axis of rotation, thus, a larger brain may be far less resistant to rotational injury. Different rat strains may exhibit different inflammatory responses and reactions to TBI [219]. Thus, the selection of strain can have a significant impact on the result. Transgenic mice and knockout models can be used to identify the impact of individual genes.

7.3.3 Notes on Experimental Design

The studies of Cernak et al. have shown that BINT is a systemic reaction to blast [165]. General inflammatory reactions from the primary blast can contribute to reactions of the brain. The propagation of pressure waves through the body in blast trauma is still a subject of controversy. Important data can be retrieved by carefully designed experiments employing partial body protection [165]. The importance of recurrent mild TBI for development of late injuries has been documented in sports medicine [101] and repeated injuries will probably be included in a number of protocols for research on BINT. Refined behavioural tests with a high sensitivity for stress reactions similar to post-traumatic stress will be important in the future work with BINT [197], [220], [221].

7.4 TRANSLATION BETWEEN CLINICAL AND EXPERIMENTAL DATA

The most central problem, however, is that exposure data from actual clinical situations are lacking. Acceleration probes mounted in helmets [222] may help to solve this problem, and if the same type of sensors is implanted for use in animal experiments, translation of findings may be facilitated. Another way to accomplish a better translation between animal and clinical experiments would be to employ the same methodology for analysis [223]. Imaging with MRI and systematic use of biomarkers can be used in both settings, to help to bridge the gap between the lab bench and the human TBI. Computer simulation represents a possible link between experiments and studies of human cases. However, in order for mathematical simulations to be completely useful, predictions will need to be validated by detailed data from animal experiments. Some aspects of neurotrauma can conceivably be studied in vitro. However, factors such as systemic response, brain edema, inflammation, vasospasm or changes in synaptic transmission and behaviour must be evaluated in experimental animals. As well, since cognitive assessment of military personnel should include functioning in everyday activities [176], blast-injured animals should be evaluated according to ecologically appropriate, species-specific behaviours. Moreover, one must also consider the significant differences between humans and animals with respect to metabolic rate, life span, etc., when attempting to match clinical and experimental time points [223]. The lack of exposure data from clinical cases makes it very difficult to propose suitable models for experimental studies [224]. Experimental studies are necessary to generate a full understanding of thresholds and consequences, as well as injury profiles for primary, secondary, tertiary, and quaternary blast injuries. One problem that results when comparing clinical and experimental studies is the mismatch between the employed techniques. It would be of value if experimental studies could employ similar imaging protocols to those used in the clinical setting. Biomarkers may also be very useful to connect clinical and experimental studies [225]. Injury reconstruction [226] and finite element modeling can also be of value to bridge the gap between clinical data and studies on experimental animals, provided that these can be validated by biological findings. With carefully designed models and thoroughly evaluated animal data, it should be possible to achieve a translation of findings between animal and human studies.

7.5 CONCLUSIONS

There is not enough information to determine whether a primary blast alone can induce mild TBI with physical lesions in the brain, or if other blast injury components are required. Experimental studies have revealed functional changes, but the coupling between clinical cases and experimental research is not sufficient to say if any of these functional changes are crucial for development of clinical symptoms of mild TBI or PTSD.

Chapter 8 – REFERENCES

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Annex A – EPIDEMIOLOGY QUESTIONNAIRE AND MEMBER NATION AND PARTNER RESPONSES

A.1 METHODS

The work group investigated the current epidemiology of MTBI for each member country's military population serving in Afghanistan in order to provide context for current practices in the management of these injuries. Each country participating in the NATO Task Group was asked to provide answers to the questions listed below. The data reported here summarizes each individual country's experience, as described in their separate reports.

Several Nations participating in the Task Group have taken measures to identify blast-induced injuries in theatre, within days of blast events: the Netherlands and the US established in-theatre teams to diagnose MTBI in victims of explosions within days of the events. Other Nations have conducted surveys of service members returning from Afghanistan.

A.2 QUESTIONNAIRE

- Please report the number of service members deployed from your country to Iraq by year, and separately to Afghanistan by year.
- Please report the calendar years your country was/is engaged.
- Please report the numbers sent home with medical problems (indicating number of TBI cases broken down by relevant ICD codes if available).
- Numbers of service members deployed to Iraq and separately to Afghanistan who were:
  - Diagnosed with TBI by severity; and
  - Hospitalized and treated as outpatients with TBI.
- Please indicate the general length of tours of duty, and whether these changed over time.
- Please provide your country's military operational definition of TBI and whether screening surveillance tools for TBI were in use in-theatre and/or upon return from deployment to Iraq and/or Afghanistan (please attach tools).

A.3 MEMBER/PARTNER NATION REPORTS

A.3.1 Canada

- **Number of Deployments**: 24,521 deployments of 21,422 unique individuals (1 Jan 2006 – 1 Dec 2009).
- **Length of Deployment**: 6 months, but personnel deployed to a Headquarters position deployed for 9 months.
- **Definition of MTBI**: US definition adopted by Canadian Forces in 2008: "Mild TBI in military operational setting is defined as an injury to the brain resulting from an external force and/or acceleration mechanism

from an event such as a blast, fall, direct impact, or motor vehicle accident which causes an alteration in mental status typically resulting in the temporally related onset of symptoms such as: headache, nausea, vomiting, dizziness/balance problems, fatigue, insomnia/sleep disturbances, drowsiness, sensitivity to light/noise, blurred vision, difficulty remembering, and/or difficulty concentrating." This definition was derived from other definitions derived in civilian settings including, the American College of Rehabilitation Medicine, the Centers for Disease Control and Prevention, the WHO, the National Athletic Trainer's Assn, and the Prague Sports Concussion Guidelines.

- **Mechanism of Injury**: Blast remains the predominant mechanism of injury in recorded TBI cases (75% of all in-theatre TBI hospitalization (mild to severe) and 67% of all cases of self-reported MTBI. Self-reports include multiple mechanisms of injury.

- **Case Ascertainment**: In-theatre case ascertainment is symptom-based. Canada does not conduct incident/ event-based screening. Surveillance of cases is largely captured through self-reporting at Enhanced Post-Deployment Screening conducted 3 – 6 months post deployment. In-theatre surveillance for hospitalized cases of TBI is conducted.

- **Findings of In-Theatre Hospitalizations**: In-theatre hospitalized cases of TBI recorded in the Joint Theatre Trauma Registry admitted from 1 Jan 2006 to 1 Dec 2009: n = 83 Role 3 admissions, that included a diagnosis of head injury (17 were moderate to severe; 66 were mild).

- **Findings of Post-Deployment Screenings**: Post-deployment screening and surveillance consists of a detailed health questionnaire (PHQ-15; PCL-C; Questions 1 and 2 of the Brief Traumatic Brain Injury Screen) and an in-depth interview with a mental health professional. MTBI/concussion was reported in 117 of 1,817 respondents (6.4%). 74 (4.1%) reported an injury with being dazed/confused only – likely a very mild TBI. Self-reported MTBI/concussion was strongly related to the extent of combat exposure.

- **Natural History**: Three or more "post-concussive" symptoms were reported by 162 of the 1,808 respondents (9%), for whom complete symptom data was available. Of the 117 with MTBI, 26 reported three or more post-concussive symptoms at the time of screening (22%). Post-concussive symptoms were nearly as common in those who sustained injury without alteration in mental status. Mental health problems were highly prevalent in those screening positive for 3 or more post-concussive symptoms.

A.3.2 France

France will provide a report at a later date.

A.3.3 United Kingdom

- United Kingdom has been engaged in both Iraq and Afghanistan. Tours of duty are 6 months long.

- **Definition of TBI**: There is no single universally-accepted definition of concussion/MTBI, but the UK Defence Medical Services (DMS) policy is based on the World Health Organisation (WHO) guidelines, and is closely aligned with the US definition. The terms concussion and MTBI are considered interchangeable, but when communicating with a patient, the term concussion may be preferable.

- **Case Ascertainment**: Screening and surveillance tools are not used in theatre or on return from deployment. TBI cases are identified in Aeromed records. However, these records identify only one diagnosis code, so head injury diagnoses would not always be recorded.

Table A-1: Numbers of UK Forces Deployed in Iraq and Afghanistan 2007 – 2010.

Numbers Deployed: Op Telic (Iraq)					Op Herrick (Afghanistan)			
	Num	Yrs/Risk	Aero	TBI	Num	Yrs/Risk	Aero	TBI
2007	24,810	5,022	527	8	20,600	4,798	547	6
2008	25,170	5,740	332	0	30,920	7,814	698	4
2009	13,510	2,629	170	1	36,320	9,277	1,026	10
2010	4,840	967	18	2	40,060	10,682	1,080	11

- The number of service personnel treated for MTBI as a result of deployment is higher than the numbers recorded above. 17 service personnel were treated on the MTBI four level programme as a result of deployment to Iraq, of which 15 were Aeromed out of theatre. 331 service personnel were treated on the MTBI four level programme as a result of deployment to Afghanistan, of which 320 were aeromed out of theatre to receive treatment (although note that the aeromed was not specifically for the suspected MTBI).

A.3.4 Netherlands

- **Number of Deployments to Afghanistan**: The Netherlands has participated with approx. 25,000 troops contributing to the International Security Force.

- Length of deployment has ranged from 4 months to 1 year, with some service members deployed several times. In the period 2006 – 2010, the Netherlands was faced with approx. 200 repatriated soldiers due to battle casualties for a variety of reasons, among which were consequences of IED blasts. When moderate and severe cases were excluded, no mTBI cases could be identified in the soldiers that were assessed since November 2009. In the acute phase, the MACE was found to be helpful in structuring the assessment. It was appreciated that immediate in-theatre assessment could prevent retrospective bias when asked about event-related aspects later. Of all MACE assessment on T1 (n = 98), as well as the detailed follow-up assessment (T2), soldiers showed few cases of PTSD (n = 2), again no cases of mTBI on clinical assessment. However, fatigue and subjective concentration problems were found in resp. 12 and 21%. The impact of the event was reported as mild in most cases.

- We concluded that in the acute phase MACE was helpful to structure the assessment. Immediate in-theatre assessment will prevent retrospective bias when asked about event-related aspects later. These first results show mild effects on subjective symptom reporting after blast exposure, except for fatigue and subjective concentration. Extensive neuropsychological assessment indicated a reduced ability to store new information and an impairment of the long-term memory in a significant group. A limitation affecting the interpretation of these data is the absence of a comparison to a control group – yet, the performance is remarkable and will need to be followed up. Careful recording of the effects of blast exposure through targeted screening and structured assessment is essential to evaluate symptom onset, as well as possible long-term effects.

A.3.5 Sweden

- Sweden has been contributing armed personnel to the ISAF force since 2002, with 500 personnel each year.

- Injuries due to attacks have increased from very few in 2007, to at least 9 injured soldiers in 2010. Most injuries have been orthopedic; no severe TBIs have been reported.

- No regular screening for MTBIs has been implemented, but it has been discussed. It is hoped that the system for detecting and reporting injuries will be improved and the work of HFM-194 will probably assist that effort (Marten Risling, and colleagues).

A.3.6 United States

- The US has been engaged in Iraq since March, 2003 (currently in support of Iraqi forces); and in Afghanistan since October 2001.

- **Definition of TBI**: DoD/DVA definition described above in Canada's report.

- **Number of Deployments to Afghanistan**: At the peak of operations in Iraq and Afghanistan, the US contributed over 100,000 US troops.

- Length of Deployment has ranged from 6 months to 1 year, with small percentage of service members deployed in Iraq for up to 18 months. A smaller percentage has also serve on multiple deployments.

- **Case Ascertainment**: In-theatre case ascertainment is acquired from the Theater Medical Data Store. This data is reliable only from May, 2008 onward and the data reported here is from that time period. These data are acquired from medical encounters in theatre. A second in-theatre method of identifying cases of TBI is incident case reporting (not available as of yet) on the ground after an event. The Post-Deployment Health Assessment conducted upon return to home base (or while awaiting transport home) includes several screening questions designed to identify individuals who may have acquired TBI in theatre. Individuals self-reporting such injuries are referred for clinical evaluation as symptoms indicate. These screening questions are based upon the Brief Traumatic Brain Injury Screen and the Department of Veterans' Affairs screening instrument.

- **Findings of In-Theatre Medical Encounters**: In-theatre medical encounters recorded in the Blast Exposure and Concussion Incident Report indicate 2260 MTBI cases in the period from August 2010 through December 2013 in Afghanistan, and 333 MTBI cases for the same period in Iraq. The codes are based upon ICD codes defined as MTBI.

Annex B – EXPLANATION OF NATO ROLE/ECHELON SYSTEM

The term "Role" or "Echelon" is used to describe the stratification of the four tiers in which medical support is organised, on a progressive basis, to conduct treatment, evacuation, resupply, and functions essential to the maintenance of the health of the force. "Echelon" or "Role" is defined on the basis of capabilities and resources, and is not specific to particular medical unit types. The term "role" is used by land or air forces, while "echelon" is primarily a maritime term. While closely related, they are not exactly interchangeable. The treatment capability of each role/echelon is intrinsic at the higher level, e.g., a Role 3 facility will have the ability to carry out Role 2 functions. Each level of support has the responsibility to resupply and otherwise support the levels below them. There is no requirement that a patient must necessarily pass through each echelon of care in progression during treatment and evacuation.

Role/Echelon 1 medical support is that which is integral or allocated to a small unit, and will include the capabilities for providing first aid, immediate lifesaving measures, and triage. Additionally, it will contribute to the health and well-being of the unit through provision of guidance in the prevention of disease, non-battle injuries, and operational stress. Normally, routine sick call and the management of minor sick and injured personnel for immediate return to duty are a function of this level of care.

Role 2 support is normally provided at larger unit level, usually of Brigade or larger size, though it may be provided farther forward, depending upon the operational requirements. In general, it will be prepared to provide evacuation from Role/Echelon 1 facilities, triage and resuscitation, treatment and holding of patients until they can be returned to duty or evacuated, and emergency dental treatment. Though normally this level will not include surgical capabilities, certain operations may require their augmentation with the capabilities to perform emergency surgery and essential post-operative management. In this case, they will be often referred to as Role 2+. In the maritime forces, Echelon 2 is equivalent to the land forces' Role 2+, as a surgical team is integral to this echelon. Maritime Echelon 2 support is normally found on major war vessels and some larger logistics or support vessels, and at some Forward Logistics Sites (FLS).

Role/Echelon 3 support is normally provided at Division level and above. It includes additional capabilities, including specialist diagnostic resources, specialist surgical and medical capabilities, preventive medicine, food inspection, dentistry, and operational stress management teams when not provided at Level 2. The holding capacity of a Level 3 facility will be sufficient to allow diagnosis, treatment, and holding of those patients who can receive total treatment and be returned to duty within the evacuation policy laid down by the Force Surgeon for the theatre. Classically, this support will be provided by field hospitals of various types. Maritime Echelon 3 is equivalent to land/air forces Role 3, though it will normally have increased specialty capabilities. Echelon 3 is normally found on some major amphibious ships, on hospital ships, at Fleet Hospitals, at some FLS, and at a few Advanced Logistics Support Sites (ALSS).

Role/Echelon 4 medical support provides definitive care of patients for whom the treatment required is longer than the theatre evacuation policy or for whom the capabilities usually found at Role/Echelon 3 are inadequate. This would normally comprise specialist surgical and medical procedures, reconstruction, rehabilitation, and convalescence. This level of care is usually highly specialised, time consuming, and normally provided in the country of origin. Under unusual circumstances, this level of care may be established in a theatre of operations.

Annex C – DESCRIPTION OF THE UK TREATMENT PROGRAMME

C.1 OVERVIEW

This programme was developed with reference to an MTBI treatment programme designed by Mittenberg [137] and using the model of MTBI developed by Kay [6]. It aims to enable individuals to perform better in their job and to reduce the extent that symptoms interfere with daily functioning.

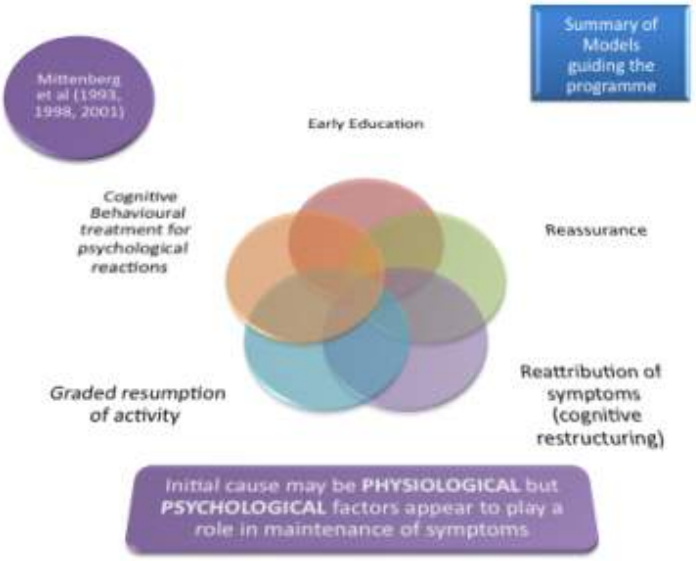

Figure C-1: Summary of Mittenberg Model Guiding the UK Treatment Programme.

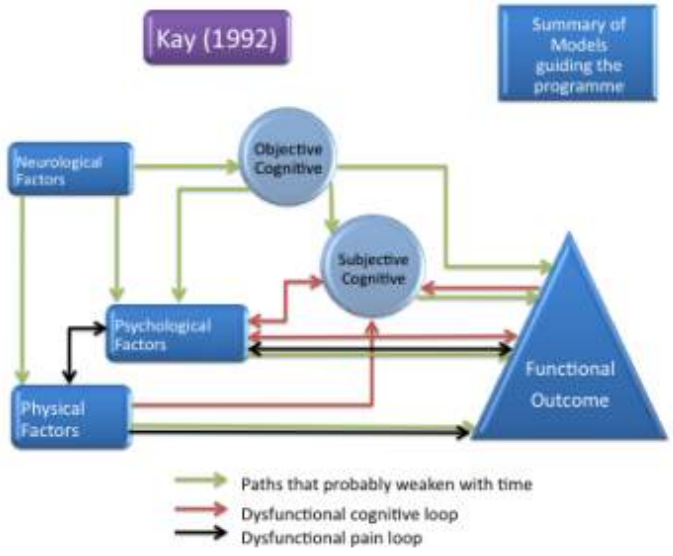

Figure C-2: Summary of Kay Model Guiding the UK Treatment Programme.

In the first few days to weeks post-injury, the common range of problems are clustered around physical and cognitive symptoms. At this stage, the symptoms typically include some or all of the items listed on the left-hand side of Figure C-3.

Figure C-3: Common Symptoms Following MTBI.

It is considered in the research literature that these symptoms are due to disruption to neurons and neurotransmitters, and that in the majority of cases this damage will resolve naturally – although it should be noted that recent research is suggesting this may not be the case when symptoms do not resolve [185], [227], [228].

In those cases where symptoms do not resolve spontaneously, a range of psychological reactions are typically seen, and these can become the dominant symptoms. At this stage, the symptoms typically include some or all of the items listed on the right-hand side of Figure C-3.

These have the effect of helping to maintain the earlier cognitive and physical symptoms in many cases – although note that this may also be due to actual ongoing neurological damage, particularly in those cases of MTBI which are closer to a diagnosis of moderate brain injury.

To treat all of these symptoms, the programme uses information from various sources (including health psychology, clinical psychology, neuropsychology, positive psychology, personal development and education fields). The aim is to help patients manage their symptoms and their reactions to these symptoms.

In many cases this leads to symptom reduction (in terms of severity, duration and/or frequency), but in those cases where symptoms remain, patients are taught how to break any dysfunctional psychological loops that are maintaining the symptoms. The ideal is to prevent such dysfunctional loops from developing in the first place – this is the role of early education and support in the time immediately following the injury (Phase 1).

The treatment programme offered at DMRC Headley Court involves four phases.

C.2 PHASE 1

Individuals who are identified as having an MTBI are given written information about MTBI symptoms and expected symptom resolution with guidance on what to do/ what not to do in order to promote recovery (www.MTBI.mod.uk). This information should be given at the point of injury.

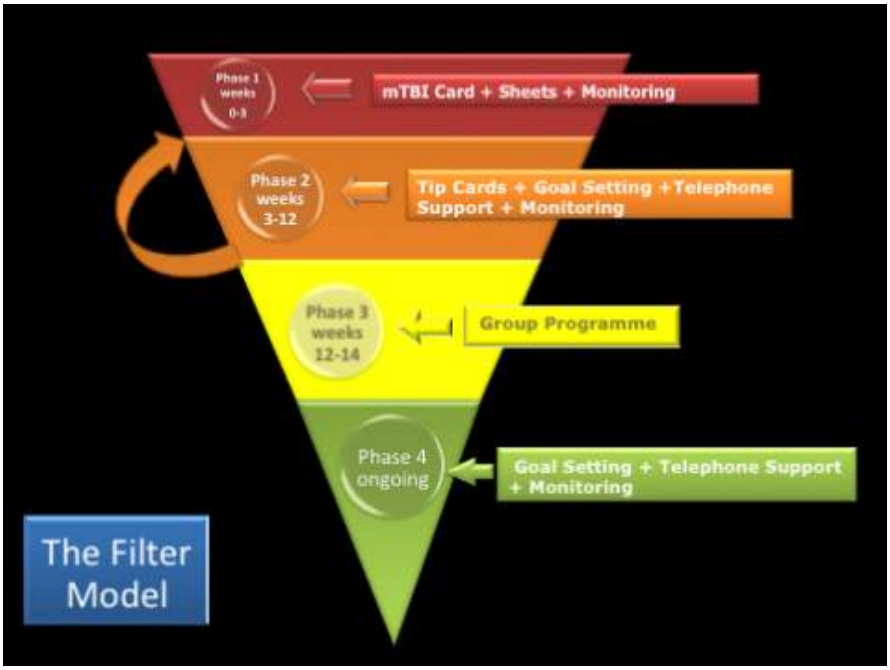

Figure C-4: The Filter Model: UK Rehabilitation Model for MTBI Treatment.

Information is also available for chain of command to support a graded return to duties.

If following Phase 1 the symptoms are not resolved, and are identified as having an impact upon functioning, the individual will be referred to the MTBI team for assessment and intervention (this may necessitate a return to the UK if the individual is deployed).

Whilst the programme developed and promulgated the materials for Phase 1 (available for open access download from www.MTBI.mod.uk), this phase is outside of the direct control of the programme.

C.3 PHASE 2

There are two referral pathways into the specialist MTBI programme at DMRC:

1) Patients attend an out-patient appointment with the Consultant i/c MTBI, who then refers them to be initially assessed by the team.
2) Patients are referred directly to be initially assessed by the team. Any patient who is already at DMRC or Birmingham can be referred in this manner as they have already been seen by a Consultant from DMRC.

Phase 2 treatment targets individuals who have symptoms, which are still present 3 weeks or more following the injury. The primary aim of this psycho-educational intervention is to reduce the symptoms themselves. Where this is not possible, the aim becomes to help patients learn to manage their symptoms in order to minimise interference with work/home demands. This is accomplished through initial interviews/rapport building, followed by telephone and web-based support systems, along with further face-to-face therapy sessions whenever appropriate and possible.

Patients are provided with a range of strategies for each of their symptoms, with guidance on goal setting, monitoring and evaluation of progress. In addition, there is a major overall emphasis on stress management, and approaches draw heavily from the Cognitive Behavioural Therapy and Positive Psychology literature. Patients are helped to manage their own stress levels (which consistently increase and/or maintain ongoing symptoms) and to reframe their thoughts about the injury and their symptoms in order to help them move towards a more positive future. This is accomplished via skilled therapeutic intervention (via phone, web and face-to-face) and provision of appropriate materials.

An individual may be entered onto the Phase 2 programme following assessment by the MTBI team at DMRC Headley Court, if their symptoms have not resolved.

At initial assessment (and then regularly during the course of treatment), the individual completes the Full Symptom Checklist. This is a 55-item checklist specifically designed to assess the current symptoms of individuals referred to the MTBI programme and was developed by combining items (with minor revisions, but no changes to content) on existing validated measures of MTBI symptoms, including: the Post-Concussion Syndrome Checklist (PSCS) [229], the Rivermead Post-Concussion Symptom Checklist (RPQ) [230], [231], the Post-concussion Checklist (PCL) [232], the Graded Symptom Checklist [233] and the Standardized Assessment of Concussion [234]. Items are grouped into the symptom domains of memory, attention and information processing, executive functions, language, emotions, social interaction and physical. The frequency and severity of any symptoms reported are rated on a four-point scale, where 4 represents greater frequency, severity or duration of symptoms.

During Phase 2, the Full Symptom Checklist is completed by the individual regularly (every 1 – 4 weeks as agreed with the therapist) using a web-based system. The therapist is able to access the system and monitor progress and identify areas for further goal setting. At the end of approximately 12 weeks of Phase 2 intervention, the individual's symptoms are reviewed and further recommendations are made:

a) Discharge with no further support required;

b) Further Phase 2 intervention;

c) Entry to the Phase 3 programme (Phase 3 treatment is an intensive two-week group programme delivered to individuals with persistent symptoms following MTBI); and

d) Referral to other services.

All participants are routinely followed up as part of the Phase 2 programme at 3 months, 6 months and 12 months.

C.4 PHASE 3

Phase 3 is designed to teach the individual about the symptoms experienced as a result of their injury, and to provide them with appropriate management strategies. Patients only enter this phase following a period of

treatment on Phase 2, and if their symptoms have still not resolved. This Phase is an intensive, face-to-face group, which is run at DMRC for a two-week period.

Phase 3 is primarily a psycho-education group based around 5 key areas:

- Education;
- Relaxation;
- Pacing;
- Adjustment; and
- Resilience.

C.5 PHASE 4

All patients who have completed Phase 3 are automatically entered into Phase 4 until all symptoms have resolved or are reported as non-problematic. Therefore, this phase is an ongoing support phase, which reinforces treatment conducted in previous phases to help individuals maintain their work, social and leisure roles.

Figure C-5: Phase 3 Treatment: UK Rehabilitation Model for MTBI Treatment.

Annex D – US DoD POLICY GUIDANCE FOR MANAGEMENT OF MILD TRAUMATIC BRAIN INJURY / CONCUSSION IN THE DEPLOYED SETTING

Department of Defense

INSTRUCTION

NUMBER 6490.11
September 18, 2012

USD(P&R)

SUBJECT: DoD Policy Guidance for Management of Mild Traumatic Brain Injury/Concussion in the Deployed Setting

References: See Enclosure 1

1. PURPOSE. This Instruction:

a. In accordance with the authority in DoD Directive (DoDD) 5124.02 (Reference (a)), establishes policy, assigns responsibilities, and provides procedures on the management of mild traumatic brain injury (mTBI), also known as concussion, in the deployed setting. See Glossary for definition of mTBI.

b. Incorporates and cancels Directive-Type Memorandum 09-033 (Reference (b)).

c. Standardizes terminology, procedures, leadership actions, and medical management to provide maximum protection of Service members.

2. APPLICABILITY. This Instruction applies to OSD, the Military Departments, the Office of the Chairman of the Joint Chiefs of Staff and the Joint Staff, the Combatant Commands, the Office of the Inspector General of the Department of Defense, the Defense Agencies, the DoD Field Activities, and all other organizational entities within the DoD (hereinafter referred to collectively as the "DoD Components").

3. DEFINITIONS. See Glossary.

4. POLICY. It is DoD policy that:

a. DoD shall identify, track, and ensure the appropriate evaluation and treatment of Service members exposed to potentially concussive events, to include blast events.

b. Service members exposed to a potentially concussive event shall be medically assessed as close to the time of injury as possible.

c. Medically documented mTBI/concussion in Service members shall be clinically evaluated, treated, and managed according to the most current DoD clinical practice guidance for the deployed environment found at the Defense Centers of Excellence for Psychological Health and Traumatic Brain Injuries (DCoE) website (Reference (c)).

d. Recurrent concussion shall be managed according to the most current DoD clinical practice guidance for the deployed setting found at Reference (c).

e. Potentially concussive events, results of concussion screening, and diagnosed concussions shall be appropriately documented, to the maximum extent possible in the Service member's electronic health record.

f. All individually identifiable information will be protected in accordance with DoDD 5400.11, DoD 5400.11-R, and DoD 6025.18-R (References (d), (e), and (f)).

g. DoD civilian employees will be treated and managed the same as military Service members to the extent practical and consistent with DoDD 1404.10 (Reference (g)).

5. RESPONSIBILITIES. See Enclosure 2.

6. PROCEDURES. See Enclosure 3.

7. INFORMATION COLLECTION REQUIREMENTS. The report on mTBI/concussion sustained in the deployment setting referred to in paragraphs 4.b, 6.e., and 8.b. of Enclosure 2 and section 3 of Enclosure 3 of this Instruction has been assigned report control symbol DD-HA(AR)2404 in accordance with the procedures in Directive-type Memorandum 12-004 (Reference (h)) and DoD 8910.1-M (Reference (i)).

8. RELEASABILITY. UNLIMITED. This Instruction is approved for public release and is available on the Internet from the DoD Issuances Website at http://www.dtic.mil/whs/directives.

9. EFFECTIVE DATE. This Instruction:

a. Is effective September 18, 2012.

b. Must be reissued, cancelled, or certified current within 5 years of its publication in accordance with DoD Instruction 5025.01 (Reference (j)). If not, it will expire effective September 18, 2022 and be removed from the DoD Issuances Website.

Erin Conaton
Under Secretary of Defense
for Personnel and Readiness

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2. Responsibilities
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REFERENCES

(a) DoD Directive 5124.02, "Under Secretary of Defense for Personnel and Readiness (USD(P&R))," June 23, 2008
(b) Directive Type Memorandum 09-033, "Policy Guidance for Management of Concussion/ Mild Traumatic Brain Injury in the Deployed Setting," June 21, 2010 (hereby cancelled)
(c) DCOE Website, "TBI Clinical Documents," http://www.dcoe.health.mil/ForHealthPros/TBIInformation.aspx
(d) DoD Directive 5400.11, "DoD Privacy Program," May 8, 2007, as amended
(e) DoD 5400.11-R "Department of Defense Privacy Program," May 14, 2007
(f) DoD 6025.18-R, "DoD Health Information Privacy Regulation," January 24, 2003
(g) DoD Directive 1404.10, "DoD Civilian Expeditionary Workforce," January 23, 2009
(h) Directive Type Memorandum 12-004, "DoD Internal Information Collections," April 18, 2012
(i) DoD 8910.1-M, "Department of Defense Procedures for Management of Information Requirements," June 30, 1998
(j) DoD Instruction 5025.01, "DoD Directives Program," October 28, 2007, as amended
(k) DoD Instruction 6200.05, "Force Health Protection (FHP) Quality Assurance (QA) Program," February 16, 2007
(l) DoD Directive 6025.21E, "Medical Research for Prevention, Mitigation, and Treatment of Blast Injuries," July 5, 2006
(m) DoD 6025.13-R, "Military Health System Clinical Quality Assurance Program Regulation," June 11, 2004
(n) Cicerone, K.D. and Kalmar, K., "Persistent post-concussion syndrome: The structure of subjective complaints after mild traumatic brain injury," Journal of Head Trauma Rehabilitation 1995; 10(3): 1-17

ENCLOSURE 2

RESPONSIBILITIES

1. UNDER SECRETARY OF DEFENSE FOR PERSONNEL AND READINESS (USD(P&R)). The USD(P&R) shall establish mTBI/concussion management policy for the DoD.

2. ASSISTANT SECRETARY OF DEFENSE FOR HEALTH AFFAIRS (ASD(HA)). The ASD(HA), under the authority, direction, and control of the USD(P&R), shall:

a. Advise the USD(P&R) on the physical and medical aspects of operationally relevant mTBI/concussion management training standards.

b. Plan, program, budget, and execute the development and fielding of new technologies and programs to support this Instruction.

3. DEPUTY ASSISTANT SECRETARY OF DEFENSE FOR FORCE HEALTH PROTECTION AND READINESS (DASD(FHP&R)). The DASD(FHP&R) under the authority, direction, and control of the USD(P&R) through the ASD(HA), shall:

a. Develop policy and provide guidance on the implementation of this Instruction.

b. Identify the capability gaps of current technologies and programs and, through the Defense Health Program, support research, development, testing, and evaluation programs to support the DoD mTBI/concussion policy.

c. Develop Force Health Protection quality assurance metrics in accordance with DoD Instruction 6200.05 (Reference (k)).

d. Develop and modify this Instruction as necessary based upon reporting summaries received from the DCoE.

e. Provide policy direction and strategic oversight to the Director, Tricare Management Activity (TMA) in the implementation of DCoE procedures.

4. DIRECTOR, TMA. The Director, TMA, under the authority, direction, and control of the ASD(HA) through the DASD(FHP&R), shall ensure the DCoE executes the following responsibilities:

a. Coordinate mTBI/concussion exposure surveillance and data analysis and promote data sharing with the Assistant Secretary of Defense for Research and Engineering (ASD(R&E)), the

Director of the Joint Improvised Explosive Device Defeat Organization, and the Secretary of the Army in his or her capacity as DoD Executive Agent for Medical Research for Prevention, Mitigation, and Treatment of Blast Injuries as designated in DoDD 6025.21E (Reference (l)).

b. Generate comprehensive, retrospective analytical reports of relevant event-triggered mTBI/concussion data and activities of the Services and Combatant Commanders and coordinate blast-specific data analyses with the Joint Trauma Analysis and Prevention of Injury in Combat (JTAPIC) Program Office. Disseminate results to Combatant Commands, Military Department Secretaries, Service Chiefs, and ASD(R&E) summarizing injury trends. Recommend modifications to the policy based upon summary reports.

c. Develop event-specific monitoring summaries in coordination with the Services and Commander of Combatant Commands.

d. Review and analyze mTBI/concussion clinical guidance to provide updates, as indicated.

5. ASSISTANT SECRETARY OF DEFENSE FOR RESERVE AFFAIRS (ASD(RA)). The ASD(RA), under the authority, direction, and control of the USD(P&R), shall ensure policies are developed that support the administrative management rules addressing the unique concerns of the Reserve Component relating to the prevention and rehabilitation of traumatic brain injury for the Ready Reserve.

6. SECRETARIES OF THE MILITARY DEPARTMENTS. The Secretaries of the Military Departments shall:

a. Develop Service mTBI/concussion policies and procedures consistent with this Instruction and recommend suggested procedural changes to the ASD(HA).

b. Program and budget for necessary manpower and resources to implement this Instruction.

c. Develop and support effective training plans for:

(1) Early detection of potentially concussive events for line leadership and Service members.

(2) Medical personnel on the use of mTBI/concussion algorithms in accordance with Service policies.

d. Develop Service reporting guidelines for potentially concussive events in accordance with section 3 of Enclosure 3 of this Instruction.

e. Ensure Service submission of monthly tracking reports to the JTAPIC Program Office.

f. Support medical management and event tracking and follow-up medical care for Service members.

7. CHAIRMAN OF THE JOINT CHIEFS OF STAFF. The Chairman of the Joint Chiefs of Staff shall:

a. Incorporate this Instruction into relevant joint doctrine, training, and plans.

b. In consultation with the Commanders of Combatant Commands and the Secretaries of the Military Departments, monitor the execution of this Instruction.

c. Monitor compliance with the requirements for documented tracking and reporting of Service members involved in a potentially concussive event.

8. COMMANDERS OF THE GEOGRAPHIC COMBATANT COMMANDS. The Commanders of the Geographic Combatant Commands, through the Chairman of the Joint Chiefs of Staff, shall:

a. Develop command-specific procedures for Service component reporting of potentially concussive events and support training programs for leaders on event-triggered screening guidelines.

b. Submit monthly tracking reports of potentially concussive events to the JTAPIC Program Office for Service members in accordance with section 3 of Enclosure 3 of this Instruction.

c. Monitor Service component compliance of monthly reporting requirements and quality management.

ENCLOSURE 3

PROCEDURES

1. POTENTIALLY CONCUSSIVE EVENTS. Events requiring mandatory rest periods and medical evaluations and reporting of exposure of all involved personnel include, but are not limited to:

a. Involvement in a vehicle blast event, collision, or rollover.

b. Presence within 50 meters of a blast (inside or outside).

c. A direct blow to the head or witnessed loss of consciousness.

d. Exposure to more than one blast event (the Service member's commander shall direct a medical evaluation).

2. COMMAND GUIDANCE

a. Commanders or their representatives are required to assess all Service members involved in potentially concussive events, including those without apparent injuries, as soon as possible using the Injury/Evaluation/Distance (I.E.D.) checklist (see Figure).

Figure. I.E.D. Checklist

Injury	Physical damage to the body or body part of a Service member?	(Yes/No)
Evaluation	**H** – Headaches and/or vomiting?	(Yes/No)
	E – Ear ringing?	(Yes/No)
	A – Amnesia, altered consciousness, and/or loss of consciousness?	(Yes/No)
	D – Double vision and/or dizziness?	(Yes/No)
	S – Something feels wrong or is not right?	(Yes/No)
Distance	Was the Service member within 50 meters of the blast? Record the distance from the blast.	(Yes/No) Not Applicable

b. Service members will be referred for a medical evaluation if involved in a potentially concussive event as defined in section 1 of this enclosure, if there is a "Yes" response on the I.E.D. Checklist, or if they demonstrate any of the symptoms listed at any point after an injury event (see Figure). After the I.E.D. assessment is complete, record the results for each individual involved in the event and submit as part of the significant activities (SIGACT) report required for blast-related events or the events outlined in paragraphs 1.a. through 1.e. of this enclosure.

3. REPORTS. The line commander is responsible to ensure all reports are completed as operational conditions permit, preferably within 24 hours. The minimum required data fields for the monthly reports to the JTAPIC are:

a. Date of potentially concussive event.

b. Type of potentially concussive event triggering evaluation.

c. SIGACT number (if applicable).

d. Personal identifier (e.g., DoD identification number or Battle Roster Number).

e. Service member's name.

f. Unit name, unit identification code, and home duty station.

g. Combatant Command in which the event occurred.

h. Service member's distance from the blast when applicable.

i. The disposition following the medical evaluation (return to duty after 24 hours, commander's justification to return to duty prior to 24 hours, or did not return to duty after 24 hours).

4. MEDICAL GUIDANCE. All deployed medical personnel must use, and commanders support, the most current clinical practice guidance for the deployed environment when possible. A complete listing of the most current guidance is provided on the DCoE website at http://www.dcoe.health.mil/ForHealthPros/TBIInformation.aspx and is summarized in this section.

a. Potentially Concussive Event. Service members involved in a potentially concussive event as described in section 1 of this enclosure are required to rest for 24 hours, beginning at the time of the event. Commanders may determine that mission requirements supersede these recommendations in certain circumstances. If the 24-hour rest period is delayed or postponed, document the circumstance in the monthly report to the JTAPIC.

b. First Diagnosed Concussion. All Service members diagnosed with a mTBI/concussion must have, at a minimum, 24 hours' recovery unless the results of subsequent clinical evaluation indicate a longer period is needed.

c. Second Diagnosed Concussion (Within a 12-month Period). If two diagnosed mTBI/concussions have occurred within the past 12 months, return to duty is delayed for an additional 7 days following symptom resolution.

d. Recurrent Concussion (Within a 12-month Period). If three diagnosed mTBI/concussions have occurred within the past 12 months, return to duty is delayed until a recurrent concussion evaluation has been completed.

(1) The recovery period for Service members experiencing recurrent concussions depends on the number of incidents.

(2) Recovery care includes uninterrupted sleep and pain management.

(3) All sports and other activities with risk of concussion are prohibited until the Service member is cleared by a licensed independent practitioner as defined in DoD 6025.13-R (Reference (m)).

(4) Commanders may impose longer recovery periods based on mission requirements and after consultation with medical personnel.

e. MTBI/Concussion Screening and Initial Evaluation. Use section one of the Military Acute Concussion Evaluation (MACE) to complete the initial screening of Service members involved in a potentially concussive event. Complete the evaluation as close as reasonably possible to the time of initial injury. If a concussion is suspected, report the results of all three scored sections in the electronic health record as follows:

(1) C - Cognitive score (reported with 30 point score).

(2) N - Neurological exam (reported as "Green" (normal) or "Red" (abnormal)).

(3) S - Symptoms reported as "A" (none reported) or "B" (at least one symptom reported).

(4) Example of summary documentation of MACE screening evaluation can be "24/Red/B" indicating a cognitive score of 24, abnormal neurological examination, and patient reporting presence of at least one symptom.

(5) Document the results of the MACE evaluation including the cognitive score, neurological examination, and symptoms in the electronic health record using the most current International Classification of Diseases codes.

5. RECURRENT CONCUSSION EVALUATION. Service members who have sustained three diagnosed concussions within a 12 month period must receive a recurrent concussion evaluation. Additionally, a recurrent concussion evaluation may be performed any time it is clinically indicated, i.e., if symptoms are persistent. Use the results of the evaluation to guide management, treatment, and return-to-duty determinations. The recurrent concussion evaluation is comprised of the following:

a. Comprehensive Neurological Evaluation. A careful examination of the injury history is required to make clinically sound decisions. Such information includes, but is not limited to, the level of mTBI/concussion severity, the nature and duration of symptoms, and the result of sustained exertion on symptoms (e.g., recurrence of headaches after 2 days of normal duty). The Neurobehavioral Symptom Inventory, a validated Acute Stress Reaction assessment, and a vestibular assessment must occur as part of this examination. The Neurobehavioral Symptom Inventory tool can be obtained by accessing http://www.dvbic.org/images/pdfs/Clincal-Tools/F--Neurobehavioral-Symptoms.aspx.

b. Neuroimaging. Neuroimaging will be initiated according to current clinical practice guidelines and evidence-based practices.

c. Neuropsychological Assessment. A variety of neuropsychological assessment tools are available as clinically indicated. No one tool is recommended over another. The assessment, if conducted, should include an effort measure. The following are examples of domains that can be affected by concussion and should be evaluated.

(1) Attention.

(2) Memory.

(3) Processing speed.

(4) Executive functioning.

d. Functional Assessment. The evaluating rehabilitation provider may initiate a functional assessment based on his or her clinical judgment. Rehabilitation providers should evaluate the Service member's performance and monitor symptoms before, during, and after functional assessment. Selected assessment activities should concurrently challenge specific vulnerabilities associated with mTBI including cognitive, sensorimotor, and physical endurance.

e. Duty Status Determination. The neurologist or other qualified licensed independent practitioner trained according to Service policies in the care of mTBI/concussion will determine the return-to-duty status after reviewing the results of the recurrent concussion evaluation. Medical providers must be vigilant for persistent signs and symptoms of mTBI/concussion with any recurrent concussion, as there is an increased risk of longer recovery time with multiple concussions.

GLOSSARY

PART I. ABBREVIATIONS AND ACRONYMS

ASD(HA)	Assistant Secretary of Defense for Health Affairs
ASD(RA)	Assistant Secretary of Defense for Reserve Affairs
ASD(R&E)	Assistant Secretary of Defense for Research and Engineering
DASD(FHP&R)	Deputy Assistant Secretary of Defense for Force Health Protection and Readiness
DCoE	Defense Center of Excellence for Psychological Health and Traumatic Brain Injury
DoDD	Department of Defense Directive
DoDI	Department of Defense Instruction
I.E.D.	injury/evaluation/distance
JTAPIC	Joint Trauma Analysis and Prevention of Injury in Combat
MACE	Military Acute Concussion Evaluation
mTBI	mild traumatic brain injury
SIGACT	significant activities
TMA	Tricare Management Activity
USD(P&R)	Under Secretary of Defense for Personnel and Readiness

PART II. DEFINITIONS

Unless otherwise noted, the following terms and their definitions are for the purpose of this Instruction.

amnesia. A lack of memory. Amnesia related to trauma, such as concussion, can be either antegrade or retrograde.

antegrade amnesia. The inability to form new memories following the traumatic event (typically not permanent).

retrograde amnesia. The loss of memory for events that occurred prior to the traumatic event.

deployed. All troop movement of Active Component and Reserve Component personnel resulting from a Joint Chief of Staff or unified command deployment for more than 30 continuous days to a location outside the United States that does not have a permanent military treatment facility (funded by the Defense Health Program). This includes naval personnel afloat who might be subjected to concussive injuries.

effort measure. A tool used to evaluate the validity of scores obtained from a neurocognitive assessment test battery.

functional assessment. A functional assessment evaluates the service member's performance of military-relevant activities that simulate the multi-system demands of duty in a functional context.

licensed independent practitioner. Any individual permitted by law and Service regulations to provide care, treatment and services, without direction or supervision, within the scope of the individual's license and consistent with individually granted clinical privileges. This term is equivalent to healthcare provider.

MACE. A medical screening and assessment tool with four sections, three of which are scored. It was developed by the Defense and Veterans Brain Injury Center as a standardized form in which the history of a concussive event can be assessed. It also includes cognitive, neurological and symptoms sections designed to evaluate the status of a concussed Service member. This tool is available to medical personnel by e-mailing: info@DVBIC.org.

medical evaluation or assessment. A meeting between a Service member and a person with medical training such as medic or corpsman, physician assistant, physician, or nurse to ensure the health and well-being of the Service member. Components of this evaluation include reviewing the history, events surrounding the injury, review of symptoms, a physical examination, and a review of the treatment plan with the Service member.

mTBI/concussion. The diagnosis of mild traumatic brain injury also known as concussion is made when two conditions are met. In the absence of documentation, both conditions are based on self-report information.

An injury event must have occurred.

The individual must have experienced a normal structural neuroimaging by head CT or conventional brain MRI and one of the following:

Alteration of consciousness lasting less than 24 hours.

Loss of consciousness, if any, lasting for less than 30 minutes.

Memory loss after the event, called post-traumatic amnesia, for events immediately surrounding the injury that lasts for less than 24 hours.

Neurobehavioral Symptom Inventory. A 22-item assessment commonly used to aid in determining mTBI. Symptoms such as decision-making difficulty or change in taste or smell are rated on a scale of 0-4. See Cicerone and Kalmar (1995) (Reference (n)) for additional explanation.

neuroimaging. A radiographic imaging study to evaluate the brain, to include computerized tomography scan or magnetic resonance imaging.

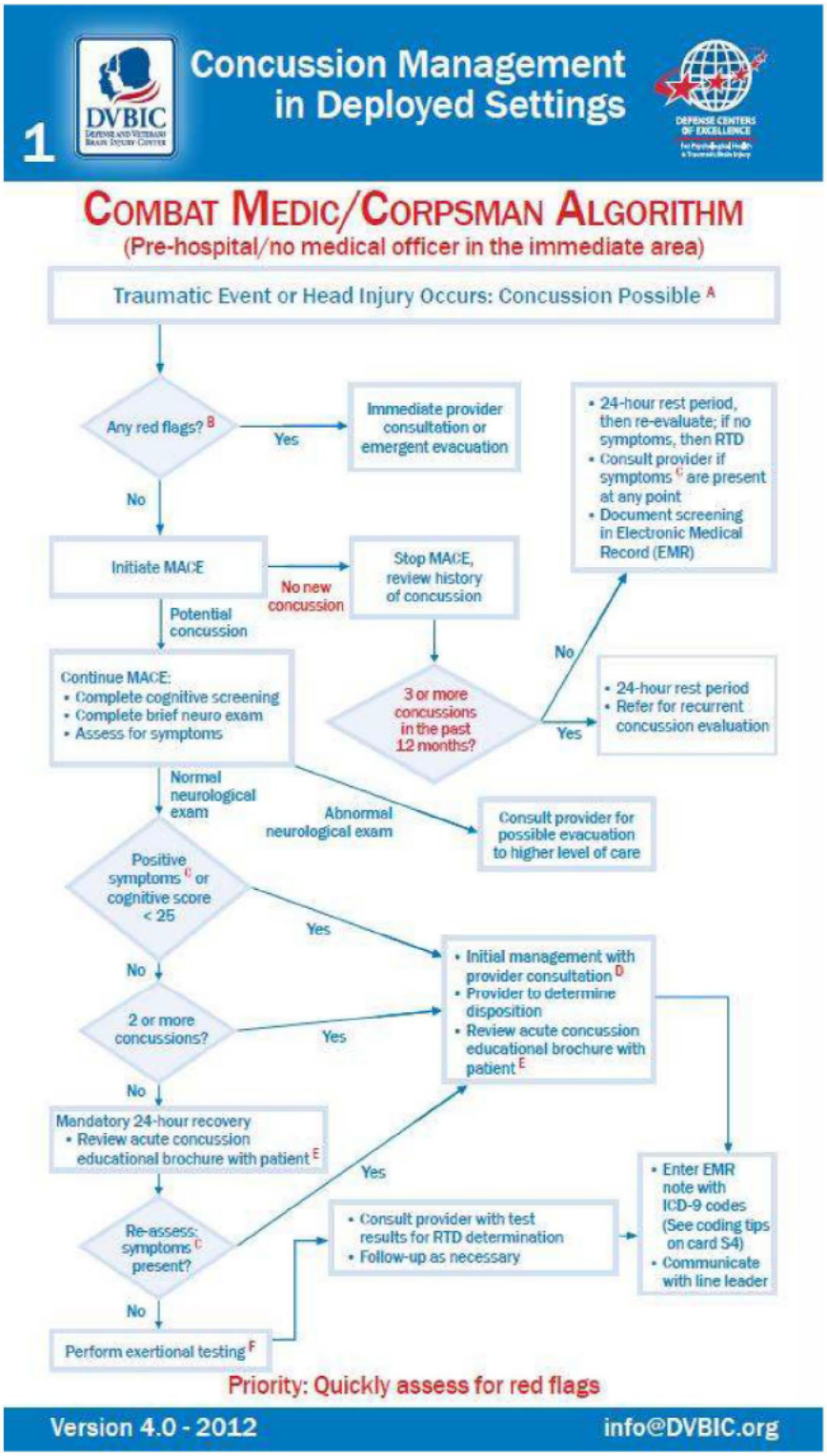
neuropsychological assessment. A series of tests carried out to assess the extent of impairment to a particular skill and to attempt to locate an area of the brain that may have been damaged after brain injury. A core part of a neuropsychological assessment is the administration of tests of cognitive functioning. Aspects of cognitive functioning that are assessed typically include attention, new-learning/memory, intelligence, processing speed, executive-functioning, and social pragmatics.

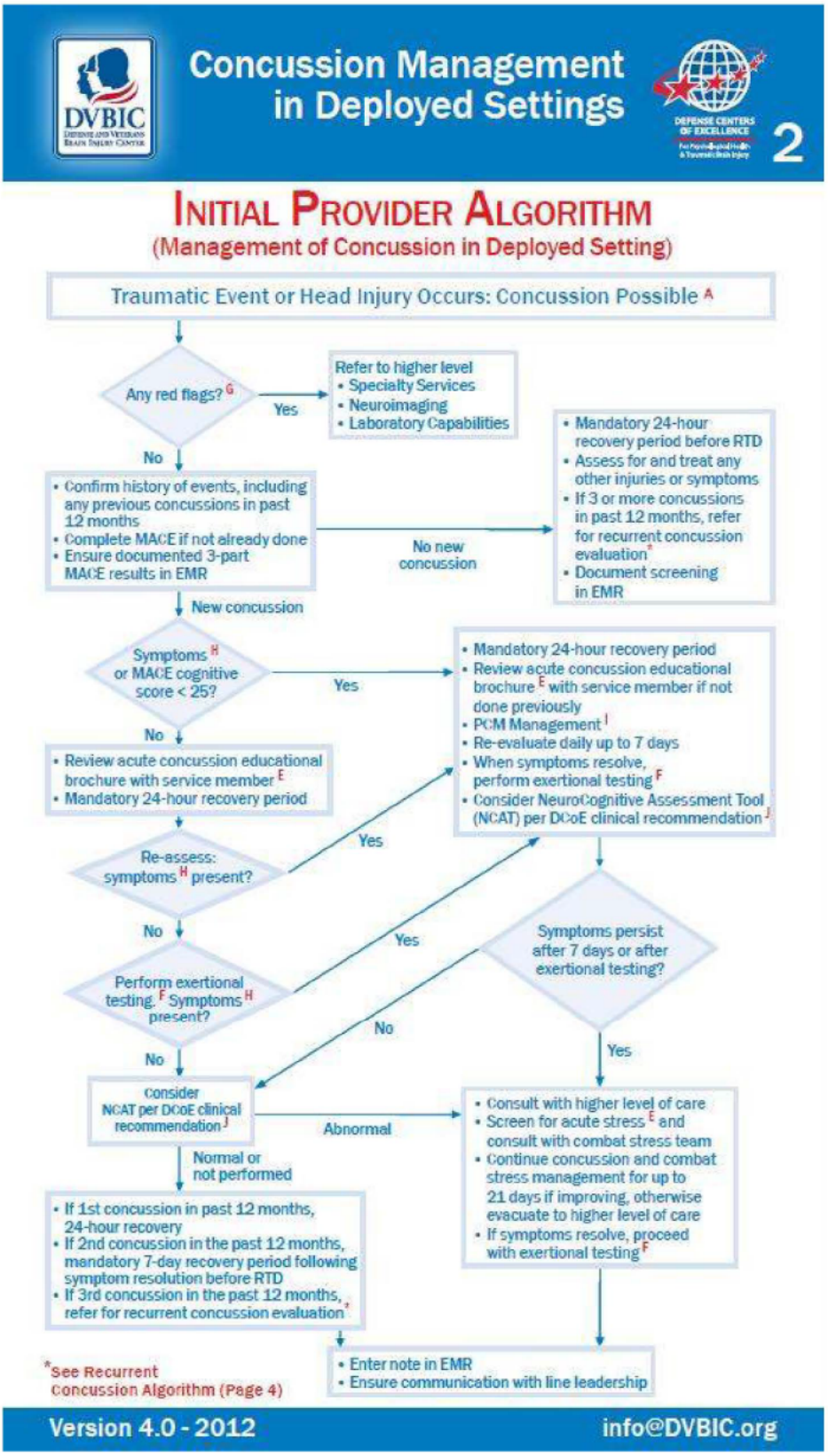
potentially concussive event. Events or incidents that may result in an individual experiencing a mTBI or concussion.

quality assurance. The systematic monitoring and evaluation of the various aspects of medical care to maximize the probability that minimum standards of quality are being met.

recurrent concussion. Three or more diagnosed mTBI/concussions within a 12 month period.

Annex E – US CLINICAL MANAGEMENT ALGORITHMS




Concussion Management in Deployed Settings
DVBIC
DEFENSE CENTERS OF EXCELLENCE
2
INITIAL PROVIDER ALGORITHM
(Management of Concussion in Deployed Setting)
Traumatic Event or Head Injury Occurs: Concussion Possible A
Any red flags? G
Yes
Refer to higher level
• Specialty Services
• Neuroimaging
• Laboratory Capabilities
No
• Confirm history of events, including any previous concussions in past 12 months
• Complete MACE if not already done
• Ensure documented 3-part MACE results in EMR
No new concussion
• Mandatory 24-hour recovery period before RTD
• Assess for and treat any other injuries or symptoms
• If 3 or more concussions in past 12 months, refer for recurrent concussion evaluation*
• Document screening in EMR
New concussion
Symptoms H or MACE cognitive score < 25?
Yes
• Mandatory 24-hour recovery period
• Review acute concussion educational brochure E with service member if not done previously
• PCM Management I
• Re-evaluate daily up to 7 days
• When symptoms resolve, perform exertional testing F
• Consider NeuroCognitive Assessment Tool (NCAT) per DCoE clinical recommendation J
No
• Review acute concussion educational brochure with service member E
• Mandatory 24-hour recovery period
Re-assess: symptoms H present?
Yes
No
Perform exertional testing. F Symptoms H present?
Yes
Symptoms persist after 7 days or after exertional testing?
No
Yes
No
Consider NCAT per DCoE clinical recommendation J
Abnormal
• Consult with higher level of care
• Screen for acute stress E and consult with combat stress team
• Continue concussion and combat stress management for up to 21 days if improving, otherwise evacuate to higher level of care
• If symptoms resolve, proceed with exertional testing F
Normal or not performed
• If 1st concussion in past 12 months, 24-hour recovery
• If 2nd concussion in the past 12 months, mandatory 7-day recovery period following symptom resolution before RTD
• If 3rd concussion in the past 12 months, refer for recurrent concussion evaluation*
*See Recurrent Concussion Algorithm (Page 4)
• Enter note in EMR
• Ensure communication with line leadership
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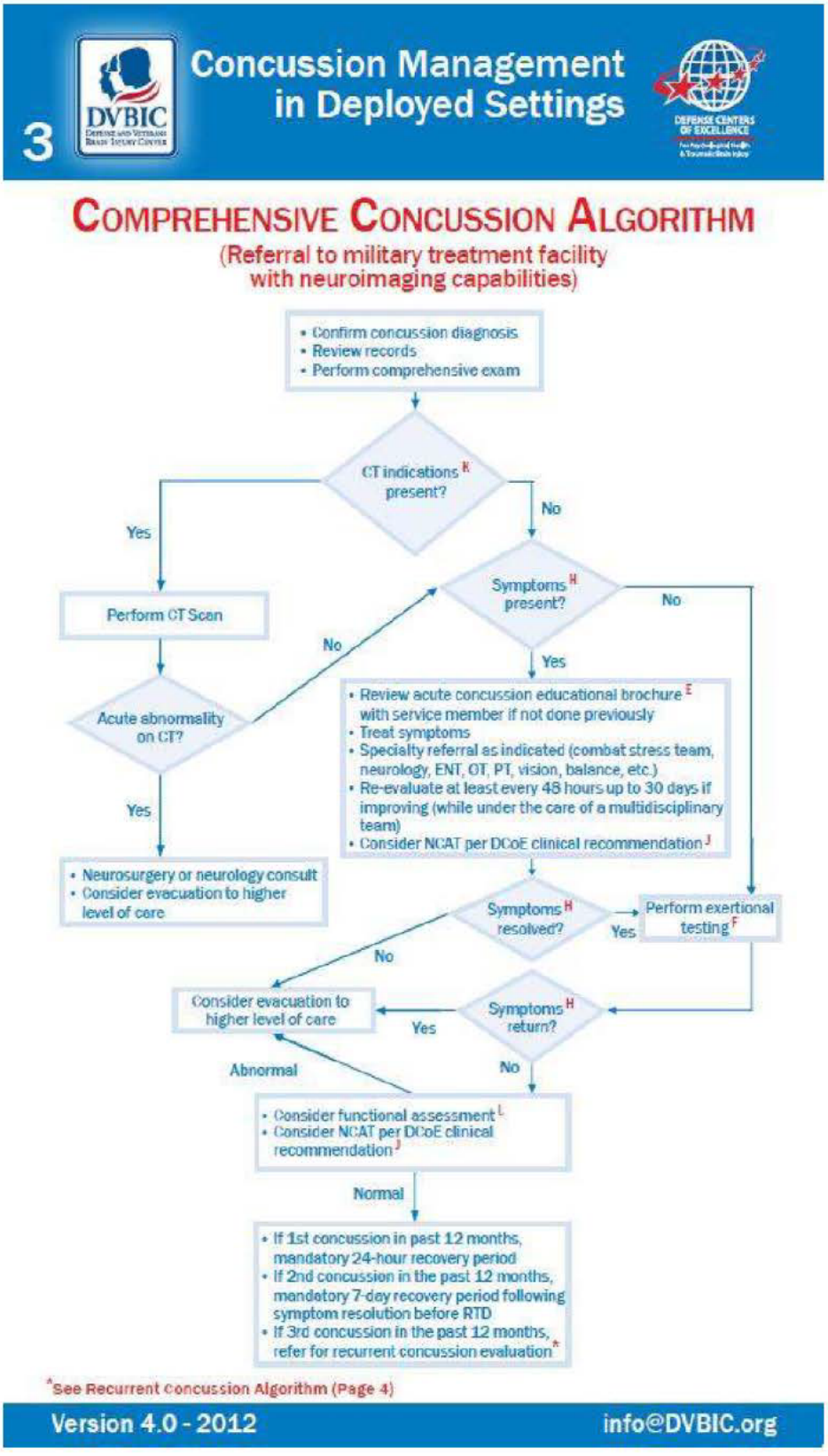
3
DVBIC
Concussion Management in Deployed Settings
DEFENSE CENTERS OF EXCELLENCE
COMPREHENSIVE CONCUSSION ALGORITHM
(Referral to military treatment facility with neuroimaging capabilities)
• Confirm concussion diagnosis
• Review records
• Perform comprehensive exam
CT indications [K] present?
Yes
No
Perform CT Scan
Symptoms [H] present?
No
Yes
No
Acute abnormality on CT?
Yes
• Review acute concussion educational brochure [E] with service member if not done previously
• Treat symptoms
• Specialty referral as indicated (combat stress team, neurology, ENT, OT, PT, vision, balance, etc.)
• Re-evaluate at least every 48 hours up to 30 days if improving (while under the care of a multidisciplinary team)
• Consider NCAT per DCoE clinical recommendation [J]
• Neurosurgery or neurology consult
• Consider evacuation to higher level of care
Symptoms [H] resolved?
Yes
Perform exertional testing [F]
No
Consider evacuation to higher level of care
Yes
Symptoms [H] return?
Abnormal
No
• Consider functional assessment [L]
• Consider NCAT per DCoE clinical recommendation [J]
Normal
• If 1st concussion in past 12 months, mandatory 24-hour recovery period
• If 2nd concussion in the past 12 months, mandatory 7-day recovery period following symptom resolution before RTD
• If 3rd concussion in the past 12 months, refer for recurrent concussion evaluation [*]
[*] See Recurrent Concussion Algorithm (Page 4)
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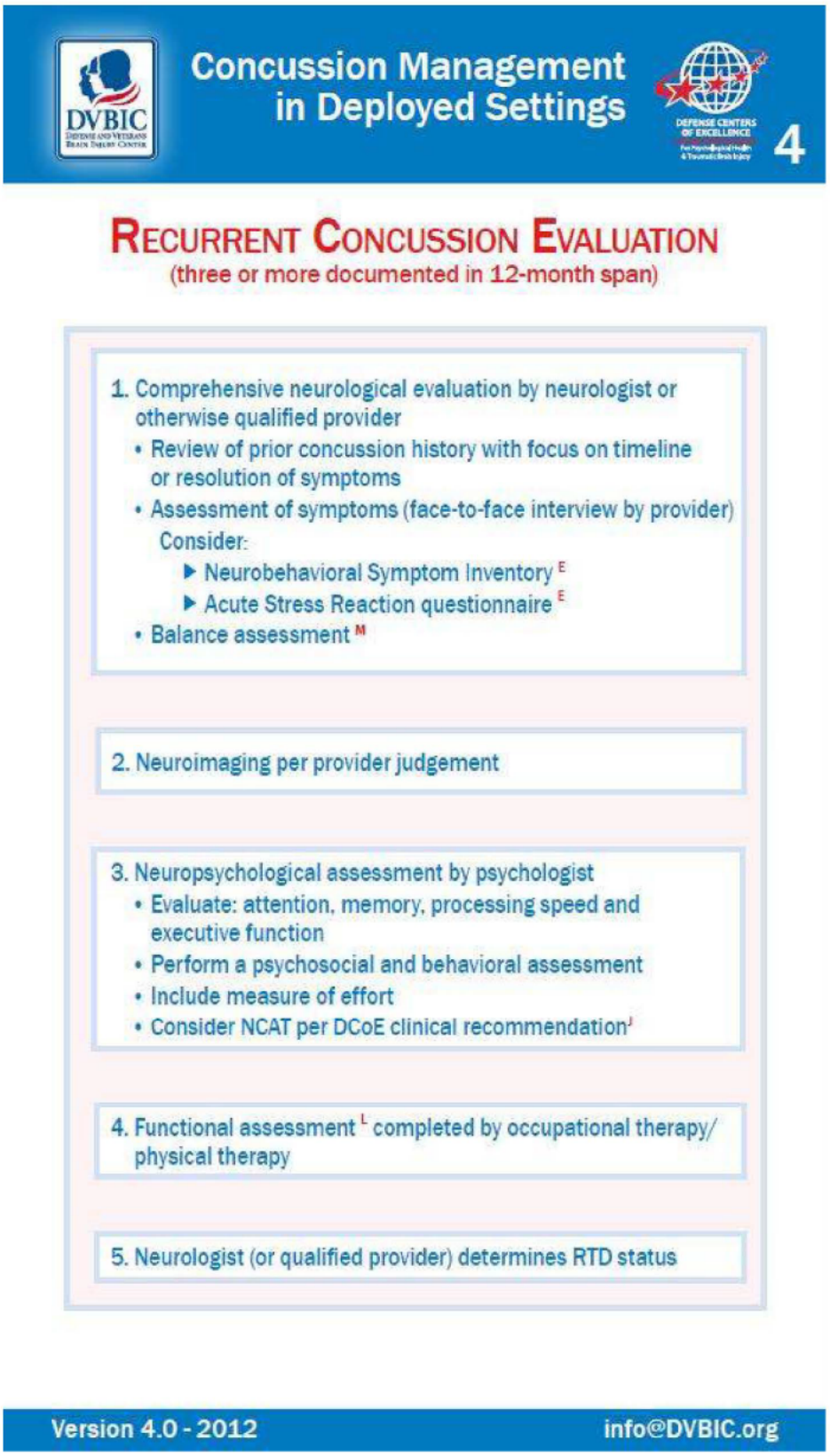
DVBIC
Concussion Management in Deployed Settings
DEFENSE CENTERS OF EXCELLENCE
4
RECURRENT CONCUSSION EVALUATION
(three or more documented in 12-month span)
1. Comprehensive neurological evaluation by neurologist or otherwise qualified provider
• Review of prior concussion history with focus on timeline or resolution of symptoms
• Assessment of symptoms (face-to-face interview by provider)
Consider:
▶ Neurobehavioral Symptom Inventory E
▶ Acute Stress Reaction questionnaire E
• Balance assessment M
2. Neuroimaging per provider judgement
3. Neuropsychological assessment by psychologist
• Evaluate: attention, memory, processing speed and executive function
• Perform a psychosocial and behavioral assessment
• Include measure of effort
• Consider NCAT per DCoE clinical recommendation J
4. Functional assessment L completed by occupational therapy/ physical therapy
5. Neurologist (or qualified provider) determines RTD status
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Traumatic Event or Head Injury Occurs: Concussion Possible

A Mandatory Events Requiring Concussion Evaluation:

1. Any service member in a vehicle associated with a blast event, collision or rollover
2. Any service member within 50 meters of a blast (inside or outside)
3. Anyone who sustains a direct blow to the head
4. Command directed – such as, but not limited to, repeated exposures

B Medic/Corpsman Algorithm Red Flags:

1. Witnessed loss of consciousness (LOC)
2. Two or more blast exposures within 72 hrs
3. Unusual behavior/combative
4. Unequal pupils
5. Seizures
6. Repeated vomiting
7. Double vision/loss of vision
8. Worsening headache
9. Weakness on one side of the body
10. Cannot recognize people or disoriented to place
11. Abnormal speech

C Medic/Corpsman Algorithm Symptoms:

(Persisting beyond initial traumatic event)

1. Headache
2. Dizziness
3. Memory problems
4. Balance problems
5. Nausea/vomiting
6. Difficulty concentrating
7. Irritability
8. Visual disturbances
9. Ringing in the ears
10. Other_____

D Medic/Corpsman Initial Management of Concussion:

1. Give acute concussion educational brochure to all concussion patients, available at: www.DVBIC.org
2. Reduce environmental stimuli
3. Mandatory 24-hour recovery period
4. Aggressive headache management
   – Use acetaminophen q 6 hrs x 48 hrs
   After 48 hours may use naproxen prn
5. Avoid tramadol, Fioricet, excessive triptans and narcotics

E Available Resources (www.DVBIC.org):

- Acute Stress Reaction Questionnaire
- Acute Concussion Educational Brochure
- Neurobehavioral Symptom Inventory
- Line Leader Fact Sheet
- Coding Guidance
- DCoE NeuroCognitive Assessment Tool (NCAT) Recommendation

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Concussion Management in Deployed Settings

S2

F Exertional Testing:

1. Exert to 65-85% of target heart rate (THR=220-age) using push-ups, sit-ups, running in place, step aerobic, stationary bike, treadmill and/or hand crank
2. Maintain this level of exertion for approximately 2 minutes
3. Assess for symptoms (headache, vertigo, photophobia, balance, dizziness, nausea, visual changes, etc.)
4. If symptoms/red flags exist with exertional testing, stop testing, and consult with provider

G Provider Algorithm Red Flags:

1. Progressively declining level of consciousness
2. Progressively declining neurological exam
3. Pupillary asymmetry
4. Seizures
5. Repeated vomiting
6. Clinically verified GCS < 15
7. Neurological deficit: motor or sensory
8. LOC > 5 minutes
9. Double vision
10. Worsening headache
11. Cannot recognize people or disoriented to place
12. Slurred speech
13. Unusual behavior

H Provider Algorithm Symptoms:

1. Confusion (24 hours)
2. Irritability
3. Unsteady on feet
4. Vertigo/dizziness
5. Headache
6. Photophobia
7. Phonophobia
8. Sleep issues

I Primary Care Management (PCM):

1. Give acute concussion educational brochure to all concussion patients, available at: www.DVBIC.org
2. Reduce environmental stimuli
3. Mandatory 24-hour recovery period
4. Aggressive headache management
   - Use acetaminophen q 6 hrs x 48 hrs
   After 48 hours may use naproxen prn
5. Avoid tramadol, Fioricet, excessive triptans and narcotics
6. Consider nortriptyline q HS or amitriptyline q HS for persistent headache (> 7 days). Prescribe no more than 10 pills.
7. Implement duty restrictions
8. Address any sleep issues. Ambien 10mg po QHS may be considered for short-term (2 weeks) sleep regulation
9. Pain management if applicable
10. Send consult to TBI.consult@us.army.mil for further guidance if needed
11. Consider evacuation to higher level of care if clinically indicated
12. Document concussion diagnosis in EMR

TBI.consult@us.army.mil is a Department of Defense email consultation service provided by DVBIC to assist deployed clinicians with the treatment of TBI and RTD decisions.

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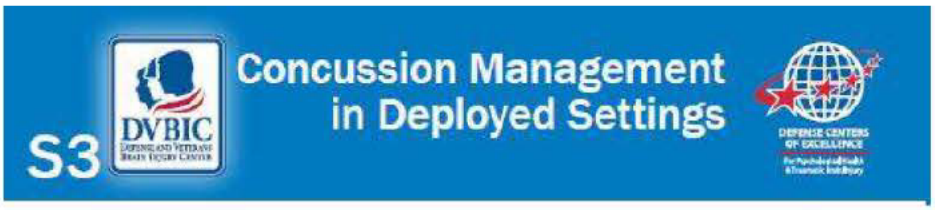

[J] DCoE NeuroCognitive Assessment Tool (NCAT) Recommendation:

Current DoD policy is that all service members must be tested with a neurocognitive assessment tool (NCAT) prior to deployment. Among several tests that are available, the DoD has selected the Automated Neuropsychological Assessment Metrics (ANAM) as the NCAT to use for both pre-deployment baseline testing and for post-concussion assessment in theater. Detailed instructions for administering a post-injury ANAM are provided at www.DVBIC.org.

For ANAM baseline results send requests to ANAM.baselines@amedd.army.mil

[K] CT Indications:*

1. Physical evidence of trauma above the clavicles
2. Seizures
3. Vomiting
4. Headache
5. Age > 60
6. Drug or alcohol intoxication
7. Coagulopathy
8. Focal neurologic deficits

* Haydel MJ, Preston CA, Mills TJ, Luber S, Blaudeau E, DeBlieux PM. Indications for computed tomography in patients with minor head injury. N Engl J Med. 2000 Jul 13;343(2):100-5.

[L] Functional Assessment:

Assess the service member's performance of military-relevant activities that simulate the multi-system demands of duty in a functional context. Selected assessment activities should concurrently challenge specific vulnerabilities associated with mTBI including cognitive (such as executive function), sensorimotor (such as balance and gaze stability), and physical endurance. Rehabilitation providers should not only evaluate the service member's performance but also monitor symptoms before, during and after functional assessment.

[M] The Balance Error Scoring System (BESS - Modified):**

Stand on flat surface, eyes closed, hands on hips in 3 positions:

1. On both feet (20 seconds)
2. On one foot (20 seconds)
3. Heel-to-toe stance (20 seconds)

For each position, score 1 point for any of the following errors:

1. Stepping, stumbling or falling
2. Opening eyes
3. Hands lifted above the iliac crests
4. Forefoot or heel lifted
5. Hip moved > 30 degrees flexion or abduction
6. Out of test position > 5 seconds

Score 10 points if unable to complete

Total Balance Score_____

** Guskiewicz KM, Ross SE, Marshall SW. Postural Stability and Neuropsychological Deficits After Concussion in Collegiate Athletes. J Athl Train. 2001 Sep;36(3):263-273.

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Concussion Management in Deployed Settings

S4

Definition of Concussion:

Anyone who has had a direct blow to the head, blast exposure or other head injury followed by at least one of the following (even momentarily):

- Alteration of Consciousness (AOC)
  - Having their "bell rung," being dazed/confused or "seeing stars"
- Loss of Consciousness (LOC)
  - Temporarily blacked out
- Post-Traumatic Amnesia (PTA)
  - Memory loss

Coding Tips:

1. Primary code (corpsman/medics require co-sign)
   - 850.0 - Concussion without LOC
   - 850.11 - Concussion with LOC ≤ 30 min.
2. Personal history of TBI in Global War on Terror (GWOT)
   - V15.52_2 - Injury related to GWOT, mild TBI
3. Symptom codes
   - As appropriate
4. Deployment status code
   - V70.5_5 - During deployment encounter
5. Screening code for TBI
   - V80.01
6. External cause of injury code (E-code)
   - E979.2 (if applicable) - Terrorism involving explosions and fragments

Key Algorithm Directives:

- Personnel are required to use the algorithms to treat concussion in the deployed setting
- Mandatory event-driven protocols for exposure to potentially concussive events
  - Requires a medical evaluation and minimum 24-hour rest period
- All sports and activities with risk of concussion are prohibited until after a 24-hour rest period
- Military Acute Concussion Evaluation (MACE) documentation will address all 3 MACE parts
- Service members diagnosed with concussion will be given the acute concussion educational brochure available at: www.DVBIC.org
- Specific protocols for anyone sustaining ≥ 2 concussions within 12 months

MACE Documentation

Document using the mnemonic "CNS"

(1) C – Cognitive score
(2) N – Neurological exam reported as normal or abnormal
(3) S – Symptoms reported as present or absent

If a head injury event or AOC/LOC/PTA is not reported, then a concussion has not occurred. The MACE is stopped because the cognitive portion is not valid in non-concussed patients. Evaluate and treat any other symptoms or injuries, and document the event in the EMR. The MACE score should be reported as N/A.

Repeat MACE Tips:

Repeating the MACE's Cognitive Exam with a different version (A-F) may be used to evaluate acute concussion recovery; however, a physical exam and symptom assessment must accompany any repeated cognitive exam. Providers should be mindful of other factors affecting the MACE cognitive score such as sleep deprivation, medications or pain.

For additional copies or information call 1.866.966.1020 or email info@DVBIC.org

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Annex F – US EVALUATION OF ACUTE CONCUSSION: MACE

MACE
Military Acute Concussion Evaluation

DVBIC — Defense and Veterans Brain Injury Center
DEFENSE CENTERS OF EXCELLENCE for Psychological Health & Traumatic Brain Injury

Patient Name: _____
Service Member ID#: _____ Unit: _____
Date of Injury: _____ Time of Injury: _____
Examiner: _____
Date of Evaluation: _____ Time of Evaluation: _____

CONCUSSION SCREENING

Complete this section to determine if there was both an injury event AND an alteration of consciousness.

1. Description of Incident

A. Record the event as described by the service member or witness.
Use open-ended questions to get as much detail as possible.

_____
_____
_____
_____

Key questions:
- Can you tell me what you remember?
- What happened?

B. Record the type of event.
Check all that apply:

☐ Explosion/Blast ☐ Fragment ☐ Motor Vehicle Crash
☐ Blunt Object ☐ Sports Injury ☐ Gunshot Wound
☐ Fall ☐ Other _____

C. Was there a head injury event?
☐ YES ☐ NO

Key questions:
- Did your head hit any objects?
- Did any objects strike your head?
- Did you feel a blast wave? (A blast wave that is felt striking the body/head is considered a blow to the head.)

MACE - Military Acute Concussion Evaluation

CONCUSSION SCREENING – continued

2. Alteration of Consciousness or Memory (AOC/LOC/PTA)

A. Was there Alteration of Consciousness (AOC)?
AOC is temporary confusion or "having your bell rung."

☐ YES ☐ NO

If yes, for how long? ____ minutes

Key question:
- Were you dazed, confused, or did you "see stars" immediately after the injury?

B. Was there Loss of Consciousness (LOC)?
LOC is temporarily passing out or blacking out.

☐ YES ☐ NO

If yes, for how long? ____ minutes

Key question:
- Did you pass out or black out?

C. Was there any Post Traumatic Amnesia (PTA)?
PTA is a problem remembering part or all of the injury events.

☐ YES ☐ NO

If yes, for how long? ____ minutes

Key questions:
- What is the last thing you remember before the event?
- What is the first thing you remember after the event?

D. Was there a witness?

☐ YES ☐ NO

If yes, name of witness: _____

Tips for assessment:
- Ask witness to verify AOC/LOC/PTA and estimate duration.

CONCUSSION SCREENING RESULTS (Possible Concussion?)

YES to 1C
AND
YES to 2A, 2B *or* 2C

↓

CONTINUE the MACE:
- Complete the Cognitive, Neurological and Symptoms portions of the MACE

NO to 1C
OR
NO to 2A, 2B *and* 2C

↓

STOP the MACE:
- Evaluate and treat any other injuries or symptoms
- Enter negative screening result into electronic medical record (V80.01)
- Communicate results with provider and line commanders
- Check for history of previous concussions and refer to Concussion Management Algorithm for appropriate rest period

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MACE - Military Acute Concussion Evaluation

COGNITIVE EXAM[a]

3. Orientation

Score 1 point for each correct response.

Ask This Question	Incorrect	Correct
"What month is this?"	0	1
"What is the date or day of the month?"	0	1
"What day of the week is it?"	0	1
"What year is it?"	0	1
"What time do you think it is?"	0	1
Correct response must be within 1 hour of actual time.		

ORIENTATION TOTAL SCORE ___/5

4. Immediate Memory

Choose one list (A-F below) and use that list for the remainder of the MACE.

Read the script for each trial and then read all 5 words. Circle the response for each word for each trial. Repeat the trial 3 times, even if the service member scores perfectly on any of the trials.

Trial 1 Script:

- "I am going to test your memory. I will read you a list of words and when I am done, repeat back to me as many words as you can remember, in any order."

Trials 2 and 3 Script:

- "I am going to repeat that list again. Repeat back to me as many words as you can remember, in any order, even if you said them before."

	Trial 1		Trial 2		Trial 3	
List F	Incorrect	Correct	Incorrect	Correct	Incorrect	Correct
Dollar	0	1	0	1	0	1
Honey	0	1	0	1	0	1
Mirror	0	1	0	1	0	1
Saddle	0	1	0	1	0	1
Anchor	0	1	0	1	0	1

IMMEDIATE MEMORY TOTAL SCORE ___/15

Immediate Memory Alternate Word Lists

List E	List D	List C	List B	List A
Jacket	Finger	Baby	Candle	Elbow
Arrow	Penny	Monkey	Paper	Apple
Pepper	Blanket	Perfume	Sugar	Carpet
Cotton	Lemon	Sunset	Sandwich	Saddle
Movie	Insect	Iron	Wagon	Bubble

MACE - Military Acute Concussion Evaluation

NEUROLOGICAL EXAM

5. Eyes

Test pupil response to light, tracking

☐ Normal

☐ Abnormal

Tips for assessment:

- Pupils should be round, equal in size and briskly constrict to a direct, bright light.
- Both eyes should smoothly track your finger side-to-side and up and down.

6. Speech

Test speech fluency and word finding

☐ Normal

☐ Abnormal

Tips for assessment:

- Speech should be fluid and effortless – no pauses or unnatural breaks.
- Assess difficulties with word finding:
  - Does service member have trouble coming up with the name of a common object?

7. Motor

Test grip strength and pronator drift

☐ Normal

☐ Abnormal

Tips for assessment:

- Assess grip strength.
- Assess for pronator drift for 5-10 seconds by directing patient to close eyes and extend arms forward, parallel to the ground with palms up:
  - Does either palm turn inward?
  - Does either arm drift down?

8. Balance

Tandem Romberg Test

☐ Normal

☐ Abnormal

Tips for assessment:

- Have patient stand with eyes closed, one foot in front of the other heel-to-toe, arms extended forward, palms up. Observe for 5-10 seconds:
  - Does the service member stumble or shift feet?

NEUROLOGICAL EXAM RESULTS

☐ All Normal — Green

☐ Any Abnormal — Red

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MACE - Military Acute Concussion Evaluation

COGNITIVE EXAM® - Continued

9. Concentration

A. Reverse Digits

Read the script and begin the trial by reading the first string of numbers in Trial 1.

Script:

- "I am going to read you a string of numbers. When I am finished, repeat them back to me backward. That is, in reverse order of how I read them to you. For example, if I said 7 - 1 - 9, then you would say 9 - 1 - 7."

Circle the response for each string.

- If correct on string length of Trial 1, proceed to the next longer string length in the same column.
- If incorrect on string length of Trial 1, move to the same string length of Trial 2.
- If incorrect on both string lengths in Trials 1 and 2, **STOP** and record score as zero for that string length. Record total score as sum of previous correct trials.

List F			
Trial 1	Trial 2 (if Trial 1 is incorrect)	Incorrect	Correct
2-7-1	4-7-9	0	1
1-6-8-3	3-9-2-4	0	1
2-4-7-5-8	8-3-9-6-4	0	1
5-8-6-2-4-9	3-1-7-8-2-6	0	1

REVERSE DIGITS SCORE (9A) ____/4

Concentration Alternate Number Lists

Note: Use the same list (A-F) that was used in Question 4.

List E	
Trial 1	Trial 2
3-8-2	5-1-8
2-7-9-3	2-1-6-9
4-1-8-6-9	9-4-1-7-5
6-9-7-3-8-2	4-2-7-9-3-8

List D	
Trial 1	Trial 2
7-8-2	9-2-6
4-1-8-3	9-7-2-3
1-7-9-2-6	4-1-7-5-2
2-6-4-8-1-7	8-4-1-9-3-5

List C	
Trial 1	Trial 2
1-4-2	6-5-8
6-8-3-1	3-4-8-1
4-9-1-5-3	6-8-2-5-1
3-7-6-5-1-9	9-2-6-5-1-4

List B	
Trial 1	Trial 2
5-2-6	4-1-5
1-7-9-5	4-9-6-8
4-8-5-2-7	6-1-8-4-3
8-3-1-9-6-4	7-2-7-8-5-6

List A	
Trial 1	Trial 2
4-9-3	6-2-9
3-8-1-4	3-2-7-9
6-2-9-7-1	1-5-2-8-5
7-1-8-4-6-3	5-3-9-1-4-8

MACE - Military Acute Concussion Evaluation

COGNITIVE EXAM[a] - Continued

9. Concentration - Continued

B. Months in Reverse Order

Script:

- "Now tell me the months of the year in reverse order. Start with the last month and go backward. So you'll say: December, November…Go ahead."

Correct Response:
Dec – Nov – Oct – Sep – Aug – Jul – Jun – May – Apr – Mar – Feb – Jan

	Incorrect	Correct
ALL months in reverse order	0	1

MONTHS IN REVERSE ORDER (9B) ___/1

CONCENTRATION TOTAL SCORE ___/5
Sum of scores:
9A (0-4 points) and 9B (0 or 1 point)

10. Delayed Recall

Read the script and circle the response for each word.
Do NOT repeat the word list.

Note: Use the same list (A-F) that was used in Question 4.

Script:

- "Do you remember that list of words I read a few minutes earlier? I want you to tell me as many words from that list as you can remember. You can say them in any order."

List F	Incorrect	Correct
Dollar	0	1
Honey	0	1
Mirror	0	1
Saddle	0	1
Anchor	0	1

DELAYED RECALL TOTAL SCORE ___/5

Delayed Recall Alternate Word Lists

List E	List D	List C	List B	List A
Jacket	Finger	Baby	Candle	Elbow
Arrow	Penny	Monkey	Paper	Apple
Pepper	Blanket	Perfume	Sugar	Carpet
Cotton	Lemon	Sunset	Sandwich	Saddle
Movie	Insect	Iron	Wagon	Bubble

MACE - Military Acute Concussion Evaluation

SYMPTOM SCREENING

11. Symptoms — Check all that apply:

☐ Headache	☐ Balance Problems	☐ Irritability
☐ Dizziness	☐ Nausea/Vomiting	☐ Visual Disturbances
☐ Memory Problems	☐ Difficulty Concentrating	☐ Ringing in the Ears
		☐ Other _____

SUMMARY

Record the data for correct MACE documentation.

Cognitive Summary

Orientation Total Score - Q3	/5
Immediate Memory Total Score (all 3 trials) **- Q4**	/15
Concentration Total Score (Sections A and B) **- Q9**	/5
Delayed Recall Total Score - Q10	/5
COGNITIVE RESULTS	/30

NEUROLOGICAL RESULTS (Page 4)	☐ Normal (Green)	☐ Abnormal (Red)
SYMPTOM RESULTS	☐ No symptoms (A)	☐ 1 or more symptoms (B)

MACE RESULTS (Report all 3 parts.) Example: 24/Red/B

Abnormality in any area should be discussed with provider.

C _____ / N _____ / S _____

Cognitive / Neurological / Symptoms

CONCUSSION HISTORY IN PAST 12 MONTHS

12. During the past 12 months have you been diagnosed with a concussion, not counting this event?

☐ YES ☐ NO

If yes, how many? _____

Refer to Concussion Management Algorithm for clinical care guidance.

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MACE - Military Acute Concussion Evaluation

ADDITIONAL INFORMATION ABOUT MACE COGNITIVE SCORES

Although cognitive is listed first in the summary of MACE results, this should not suggest that any one of the three screening categories is more or less important than the others. Each area (Cognitive, Neurological, Symptoms) must be evaluated carefully. The results of all three evaluations must be included in any MACE report for it to be considered complete.

Regarding cognitive scores, in studies of non-concussed subjects, the mean total cognitive score was 28. Therefore, a score of < 30 does not imply that a concussion has occurred. Definitive normative data for a cut-off score are not available. The Concussion Management Algorithm stipulates that a cognitive score of < 25 or the presence of symptoms requires consultation with a provider.

Repeating the MACE cognitive exam with a different version (A-F) may be used to evaluate acute concussion recovery; however, a physical exam and symptom assessment must accompany any repeated cognitive exam. Providers should be mindful of other factors affecting the MACE cognitive score such as sleep deprivation, medications or pain.

Coding Tips for Concussion:

1. Primary code (corpsmen/medics require co-sign)
   - 850.0 – Concussion without LOC
   - 850.11 – Concussion with LOC ≤ 30 min.
2. Personal history of TBI in Global War on Terror (GWOT)
   - V15.52_2 – Injury related to GWOT, mild TBI
3. Symptom codes
   - As appropriate
4. Deployment status code
   - V70.5_5 – During deployment encounter
5. Screening code
   - V80.01 – Special screening for TBI code
6. E-code (external cause of injury)
   - E979.2 (if applicable) – Terrorism involving explosions and fragments

References

a. McCrea, M. Standardized Mental Status Testing on the Sideline After Sport-Related Concussion. J Athl Train. 2001 Sep;36(3):274-279.

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REPORT DOCUMENTATION PAGE

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6. Title

Traumatic Brain Injury in a Military Operational Setting

7. Presented at/Sponsored by

This Report summarizes the findings of Task Group 193. The objectives of which were to summarize current knowledge and practices in managing mild traumatic brain injury which occurs in a military operational setting.

8. Author(s)/Editor(s)	9. Date
Multiple	January 2015
10. Author's/Editor's Address	**11. Pages**
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12. Distribution Statement

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13. Keywords/Descriptors

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War
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14. Abstract

Mild Traumatic Brain Injury (MTBI), also known as concussion, as a consequence of battlefield blast exposure or blunt force trauma has been of increasing concern to militaries during recent conflicts. This concern is due to the frequency of exposure to improvised explosive devices for forces engaged in operations both in Iraq and Afghanistan coupled with the recognition that MTBI may go unreported or undetected. Some have postulated that the injury cascade and natural history of blast-induced MTBI differs from that which occurs from impact injuries more typically seen in civilian settings. To date, there have been no controlled studies to confirm or refute this.

Consequently, this Task Group was formed in 2009 with the objectives of providing some clarity to military medical leadership to inform their decisions in the management of deployment-related MTBI. The objectives of this report were to: 1) Describe current existing clinical practice for all participating NATO Nations; 2) To identify existing gaps in knowledge; 3) Provide a summary of current research projects and predicted target dates for completion; and finally, 4) Elucidate principles for best practices.

It is hoped that this report will serve as a reference point for other NATO Nations when considering implementing or changing existing policies aimed at optimizing the management of this injury.

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